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SEVENTH FRAMEWORK PROGRAMME

Network of Excellence

NEWCOM#

Network of Excellence in Wireless Communications#

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WP4.1 – Direction and quality assurance of scientific activities

D41.4
Second yearly report on scientific management and network promotion plan

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Executive Summary

This document presents a summary of the NoE activity in the second reporting period, and illustrates the most crucial steering and coordination functions of Project Coordination. Both general achievements and specific WP and Track activities are discussed, assessing whether all WPs in the Joint Program of Activities are actually making adequate progress towards their goals and delivering the planned documentation in due time and with the expected level of quality. The document also refers about the initiatives about internal and external promotion of NEWCOM#, in particular its impact on new external affiliations from industry and Academia to the NoE.

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1. Summary of the project

1.1 Project description

NEWCOM#

Network of Excellence in Wireless COMmunications#

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Duration: November 2012 – October 2015
Total Cost: € 5,550,980

EC Contribution: € 2,845,999
Contract Number: CNECT-ICT 318306

NEWCOM# is a *research ecosystem* to nurture a new generation researchers, and to help creating Institutions featuring excellent researchers with an inherent attitude to work in line with the NoE philosophy: *interaction, cooperation, integration*. The **core concept** of NEWCOM# is an NoE of a relatively large size, created for the purpose on one hand, **to address medium-to-long term complex, interdisciplinary, fundamental research problems in the field of wireless communications and networking;** and, on the other, **to create a distributed European laboratory for the future Wireless Internet (EuWIn) to also foster experimental research in the field.**

As a consequence of this concept we may delineate the **Scientific Objectives** of NEWCOM# as follows:

1. Optimize the design of relay networks, develop capacity-achieving channel codes, propose optimal distributed signal processing techniques, develop novel network models and analyze their performance.
2. Develop algorithms and protocols to enhance the efficiency of future networks, with special emphasis on power-efficient terminals, interference management in wireless networks, and resource allocation for heterogeneous radio-access mechanisms.
3. Define suitable performance measures that take into account the wireless channel nature (ergodic and outage capacity, bit-frame error rate, etc.).
4. Study of the low-energy-consumption and low-emission technologies in the field of radio interfaces, and their interplay with high spectral efficiency (MIMO) techniques.

Beyond the research objectives, NEWCOM# has **Integration and Spreading-of-Excellence objectives,** such as:

I. Building a strong link with the EC to interface with other projects and events, and exploit possible synergies with the Future Network and Mobile Summit and the RAS cluster.
II. Offer attractive opportunities for joint teaching activities, hands-on instruction, and increased student mobility through the issue of NEWCOM# Mobility Awards, and by assisting with the preparation of proposals for other EC mobility grants (like Marie Curie Fellowships).
III. Contribute to the long-term sustainability of the NoE by creating a permanent environment for cooperative research: the EuWIn lab (multisite European Laboratory

of Wireless communication for the future Internet).

IV. Disseminate its results across the scientific community through jointly written papers, special sessions and journal issues, and improving dissemination of the research results to European industry organizing events hosted by Associate Partners at their own premises to facilitate participation of their staff members.

Further details about the expected impact of the Project, the Consortium composition and strength, as well as the Joint Program of Activity, can be found in D41.1 or on the project website http://www.newcom-project.eu.

1.2 Reviewers' recommendations concerning Y3 work

In the following, we describe the different actions carried out by the Coordinator to make sure that the recommendations for future work formulated by the EC Reviewers after the 2nd year review are taken into account. Part of the recommendations are also included and commented into Sect. 2.2 of D43.3, still, the original numbering has been kept, for clarity and consistency

1. *KPI targets should be defined for the last year of the project in order to see and follow the ambition of the project.*

The project identified the KPIs as in the table below. Full analysis of the data, including setting a target for each KPI in order to evaluate the success of the project will be done in the final project report, and will be reported in the final issue of this deliverable.

KEY PERFORMANCE INDICATORS	
KPI1	*Number of published Papers (joint & individual)*
KPI2	*Number of special issues edited*
KPI3	*Number of visiting researchers*
KPI4	*Number of PhD Students co-supervised/co evaluated*
KPI5	*Number of schools and workshop organized*
KPI6	*Number of attendees, external and internal, to schools and workshops*
KPI7	*Number of in-company dissemination events*
KPI8	*Number of unique pages of the portal visited*
KPI9	*Number of associate partners*

2. *The project period report (PPR) should not contain any duplication of information from other deliverables (recommendation #9 from previous review regarding duplication). Instead there should be a link to the relevant deliverables and a summary of* the major achievements.

It will be done.

3. *The project strategy for dissemination of results towards the industry should have more attention in order to disseminate the results directly to the industry to ensure as high impact as possible for Europe. The reporting in year 3 should include information about follow up and the involvement of SMEs.*

The dissemination plan towards industry followed its path as documented in D34.4. Cocnerning the involvement of SMEs, during the NEWCOM# Final Event *"Joint NEWCOM/COST Workshop*

on Wireless Communications JNCW 2015", held on October 14-15, 2015, Hotel Plaza, Barcelona, Spain, was organized the special SME EVENT *"When Research meets Business: Planning the Transition".*
This panel discussion focused on SMEs, startups, and their interaction/collaboration with academia. Discussions revolved around what it takes to build a successful tech company, conduct joint research activities involving academia and SMEs, lessons learnt, success stories and much more. All this from senior researchers, industry experts, and high-profile entrepreneurs belonging to NEWCOM# and its broader community.
More information on the NEWCOM# Portal:
http://www.newcom-project.eu/index.php?option=com_content&view=article&id=174&Itemid=226

Other examples of N# activities aimed at SMEs:

- One SME using flextop facility at EuWIN (CPL Concordia, from Modena).
- During the third year it was proved that EuWIn labs are effective in offering services to SMEs; CPL Concordia, an Italian SME, requested the use of the FLEXTOP facility at UniBO for testing through a downscaling approach a protocol stack for smart building applications.
- EuWin@CTTC established a cooperation with the Spanish SME, Signadyne, with which researchers involved in the GEDOMIS facility of EuWIn are preparing a joint proposal for H2020.
- It has been organized a meeting of the SME group in Networld2020 in EUWIN booth at EUCNC in Paris.

4. *The project should address specifically the issue of sustainability and relevance of EuWIn lab in particular in the long run, beyond the lifetime of the project. This information should be made available in the final PPR.*

EuWIN's OpenAirInterface software is used by more and more people both from industry and academia. It is also used in several of the recently started 5G-PPP projects, such as Coherent, SLEFNET, Flex5Gware, SESAME, FANTASTIC 5G.

Newcom# and the former COST Action IC1004 submitted a new proposal of COST Action, IRACON, representing the merge between the two communities. In particular, the Work Programme of IRACON, based on seven WGs, includes three WGs which represent the follow-up of EuWIn initiatives and spirit.
The proposal has been formally approved on October 30, 2015. The new COST Action, that will allow survival of EuWIn spirit for the next four years, will probably start in January 2016.

On a different topic, the EuWIn website has also been improved based on the comments received by the panel of EC evaluators, to simplify and better emphasize the liaisons with industries. In particular, the EuWIn home page has been revamped and now reports:

"The European Laboratory of Wireless Communications for the Future Internet addresses two separate goals: on one hand it aims at supporting industries, providing an Open Platform for Innovation; on the other it fosters a new generation of scientists willing to perform research through both theoretical and experimental approaches, under the motto "Fundamental Research Through Experimentation. Industries can find information on the EuWIn Open Platform for Innovation concept here."

More details about (industrial) dissemination events can be found in D34.4

1.3 Achievements during the third year

The activities developed in the third year of the project have been mostly compliant with the Description of Work (DoW) and the related expectations. In terms of management, all project Boards have actively worked toward the achievement of their own objectives.

The Executive Board (EB) members have met two times face-to-face, and one more using the videoconference tool SCOPIA licensed by CTTC at the beginning of the project to this purpose to all partners.

The NEWCOM# Office, has been in charge of the many day-by-day operations needed to synchronize the various activities with the deadlines set by the DoW in terms of deliverables and milestones. To be noticed that Marian Ramirez (CTTC) replaced Eva Hernandez CTTC) since November 2014.

The Advisory Board (AB) has met in Barcelona in October 2015 during the NEWCOM# Final Event, has received a presentation of the activity in Y3 of the project and the ideas for the future of the Network, and will examine all the documentation to edit a final report including further comment, specially for the survivability of the project know-how.
This report will be included in the Periodic Report.

The NEWCOM# web site www.newcom-project.eu will remain fully operational several months after the end of the project and fulfils its role of repository of the working WP documents and materials, as well as a source of information for all network researchers and external users as a dissemination instrument. It has been enlarged with further sections, in constantly updated with more material and news, and is fully integrated with the "twin" website of EuWIn www.euwin.org.

Track 1, about fundamental and theoretical research, has issued three very "dense" deliverables that report i) an introduction to the general subject the WP is concerned with, ii) the description of the Joint Research Activities that has been carried out within the various WPs, with the final results, and iii) conclusions and prospects. They all follow a common format resulting from the Reviewers' remark after Y1 review. Integration with Track 2 has been fostered with the organization of a specific inter-Track meeting in Athens (Greece) in Jan. 2015.

Main achievements of Track1 are:

- The many results published by S. Shamai, and co-authors of other N# partners on the characterization of MAC / wiretap channels / compound broadcast channels with feedback and many other situations. Shlomo mentors young colleagues and in turn is solicited on some topics of interest.
- Polar Coding technique developed by E. Arikan has been awarded several IEEE prizes and is the focus of strong interest from large industrial players such as Huawei and Samsung. Polar coding has been named by as the error-correction method of choice for a new air interface developed by Huawei (http://pr.huawei.com/en/news/hw-415869-5g.htm#.VVLm05PeKoA)
- One of JRA of WP 1.3 succeded in put altogether:
  - Theoretical results for analyzing performance
  - Proposal of new algorithms, taking into account the context
  - Experiments
  - Feedback towards algorithmic studies
  - All this by researchers who did not have previous exposure to practical experiments.

Track 2, "the European Laboratory of the Future Wireless Internet EuWIn", has also issued three deliverables with the same overall organization as the deliverables in Track 1. The documents focus on the experimental activities carried out at the different sites of the lab (CTTC, CNIT/UniBO, CNRS/Eurecom), with particular emphasis on relation with external partners, that represents one of the best outcomes and "success stories" of the Track. Document D22.3 is supplemented by the Annexes containing i) a validation document of the facilities at the EuWIn sites (D22.3 Annex II), and ii) the integration document already mentioned in the previous section (D22.3 Annex III).

Main achievements of Track2 are:

- During 2014 NEC Labs Europe established a contract with EuWIn@UniBO to use the FLEXTOP facility for measurements to be used within the HGI (Home Gateway Initiative).
- Several ExpressMIMO2 software radio cards (which is one hardware platform that can be used with OpenAirInterface) have been sold to members of the Newcom# network, such as such as IASA, KCL, and Alcatel-Lucent Bell Labs Nozay (Paris).
- EuWin@CTTC has incubated an open source project implementing a Global Navigation Satellite Systems (GNSS) receiver, freely available at http://gnss-sdr.org. Along the past three years, the project has achieved some significant milestones (e.g., be the first open source receiver to obtain position fixes using uniquely satellites from the Galileo constellation), attracting the interest from industry and academia, getting involved in projects, and becoming a reference for software-defined GNSS receivers.

All research deliverables have been released in due time (with a short extension for D31.2 agreed with the Project Officer) and in addition, 79 joint papers and 94 individual papers with project acknowledgement have been presented at international conferences or accepted/published by international peer-reviewed journals. Publications, can thus be regarded as one of the main achievements of the project in the third year (as happened in Y1 and Y2). It is true that the total count of publications in Y3 is smaller than in Y2, but this is also due to the fact that part of the work done in Y3 will actually appear in publications after the project is over. In Section 3, we carry out an in-depth analysis of those publications and other dissemination activities carried out by NEWCOM# partners. The complete list of publications can be found in Annex V.

Track 3 has developed through a number of dissemination activities. Direct scientific dissemination have concerned various contributions to international conferences in terms of special sessions organized by NEWCOM# researchers, as well as the usual launch and publication of a few special issues in international journals with editorial committees assembled within NEWCOM#. One of the main outcomes of the period has also been the contribution in terms of tutorials, workshops, and special sessions to the Conference EuCNC in Paris in June 2015 and the Final Event Joint NEWCOM#/COST Workshop on Wireless Communications JNCW'2015, held on October 14 -15, 2015, in Barcelona, Spain. The JNCW15 was a very successful event, in terms of the scientific quality of the contributions, the technical discussions maintained, networking activities and, attendance level too: almost 100 registered attendees for the entire workshop!! The event counted the participation of two wonderful keynote speakers like Profs. Andrea Goldsmith and Javier Gozálvez, from Stanford and Miguel Hernández universities, respectively, and a distinguished lecture from Prof. Sergio Benedetto, the founder of the NEWCOM series; 6 demo booths, 17 posters, and 44 oral presentations, this including regular, TD, and invited papers. The event also features the so-called **SME event**. In a two-hour session, a number of senior researchers, industry experts, and high-profile entrepreneurs discussed on what it takes to build a successful tech company, lessons learnt, success stories and much more. And, interestingly enough, the SME event attracted additional audience, via remote and physical attendance.

Main achievements are:

- Dissemination through liaison with industries has been carried out organizing three dissemination events: at Telecom Italia, Turin, Italy, 26 February 2015; Ericsson, Stockholm, Sweden, 4 May 2015; Telefonica, Madrid, Spain, 16 June 2015.
- Next, several small and medium enterprises (SMEs) were invited to a panel targeted to entrepreneurship organized during the first day of Final NEWCOM#/COST event JNCW'2015. The list of third year events is as follows:
- Training has also developed though the organization of three one-week schools, devoted to PhD students and young researchers to help them in choosing and focusing their research activity. The schools were held in Torino (Italy), Barcelona (Spain) and Sophia Antipolis (France).
- A training session was held in Sept. 2015 in conjunction with the WaveNAT summer school at Eurecom in Sophia Antipolis (France).
- The third Emerging Topics Workshop in "Advances in Coding and Information Theory" was held at the University of Cambridge on June 25-26, 2015 and was well attended.
- Valorization of human capital has been achieved through the launch of the calls for selection of two Best Paper Awards and Best Student's Paper Awards, and the Distinguished Researcher Award. The Award Ceremony was held during the social dinner of the Final Event in Barcelona.
- NEWCOM# is also contributing to the EC Concertation activities.

The project did not encourage any more associate partners to join during the last year of activity since a late arrival of further partners was considered not fruitful neither for the NoE nor for the partner itself (too short a time to actually build significant cooperation).

- Finally, under Track 3, NEWCOM# has prepared during Y3 four (4) issues of the Newsletter that can be found here:

http://www.newcom-project.eu/index.php?option=com_content&view=article&id=23&Itemid=113 and describe in close detail the everyday life and of the NoE and the persons that are involved into research.

In the Coordinator's opinion, NEWCOM# has fulfilled in a more than satisfactory manner its third year goals, and concludes its activity with an established set of actions, as well as a good plan for project survivability. On the negative side, the only aspects worth mentioning is a perceived "discouragement" into proposing and contributing to joint activity during the last year of the project, for some partners more than others. The certainty that there will be no opportunities of NoEs in the future may have partially generated this attitude

2. Project activities in year 3

In this section, a detailed description of the activities developed during Y3 of the project is reported for each of the work packages identified in the DoW. As the individual descriptions show, the work progress did not significantly deviate from the work plan: all the deliverables of Y3 have been produced and delivered in time, and the milestones have been achieved with a few minor delays approved by the Contract Officer. So, the project is in line with its expectations.

2.1 Project objectives for the period

As was done in the corresponding deliverable of Y1 D41.1 and Y2 D41.3, we will make a distinction between MACRO objectives and MICRO objectives of our work. The description in terms of micro-objectives is the subject of the detailed activity report that is done on a WP basis in a later section, whilst we just discuss here the macro-objectives of the projects in Y3 on a synthetic Track-by-Track approach.

The main objective of the WPs in Track 1 was continuing and consolidating the approach to joint theoretical research, through a number of Joint Research Activities. At the end of Y1 we had 35 JRA in total (Track1/2), in Y2 they were 31 in Track 1 and in Y3 have been 30 in Track 1. In Y3 we noticed a slight decrease in the number of publications from a total of 77 publications joint/individual in Y1 to 171 in Y2 and 132 in Y3), partially due to the fact that some work actually done in Y3 will be published after the project is over.

Track 2 features now a consolidated structure of the EuWIn lab sites (certified by the validation document, Annex II of D22.3), and a number of experimental activities; as already mentioned, JRAs were at the end of Y1 35 in total (Track1/2), in Y2 they were 13 in Track 2 and in Y3 have been 19 in Track 2. On top of this, what has also come is the interest and recognition of the work done coming from external companies and Institutions. As happened in Y2, there has been a record of involvement on experimental activities of researchers coming from external Institutions, as well as a number of activities carried out jointly and on behalf of external companies. The latter (external recognition and access) was from the onset of the NoE one of the main objectives of EuWIn.
The progress of publications in Track 2 is satisfactory: from a total of 24 publications joint/individual in Y1 to 43 in Y2 and 41 in Y3.

Coming to Track 3, the objectives were mainly of further developing the various activities already launched in Y1 and Y2. This was done as planned, we just wish to mention the organization of *three* training schools in Y3, i.e., one more than was planned; it is a total of two additional schools in the three years of the Project (one more in Y" and one more in Y3).
Details on the many micro-objectives that the project has successfully reached is reported in Track 3 deliverables.

The objectives of Track 4 in terms of scientific management were those of a close coordination between the scientific activities of Track 1 and Track 2, and this was achieved through organization of a joint workshop held in January 2015 in Athens, plus a number of discussions and resulting coordination actions at the many meetings of the Executive Board (see the detailed list reported later on). And last but not least, promotional material has been disseminated at many occasion with good acceptance.

2.2 Work progress and achievements during the period

We recall that the general organization of NEWCOM# revolves around three main axes

called Tracks: 1) Theoretical research, 2) Experimental research, 3) Dissemination, Training and Human Capital, 4) Management. This deliverable reports on the main work and achievements from Track 1 to Track 3, whereas those corresponding to Track 4 can be found in the companion deliverable D43.3 ('Administrative Management').

2.2.1 TRACK 1

Track leader: Pierre Duhamel (CNRS)

In the "Theoretical Research" Track, NEWCOM# pursues medium to long term, interdisciplinary research on the most advanced aspects of wireless communications like the Computation of the Ultimate Limits of Communication Networks, Opportunistic and Cooperative Communications, or Energy and Bandwidth Efficient Communications and Networking.

WP 1.1 Performance Limits of Wireless Communications

WP Leader: Michel Kieffer (CNRS/UniPS)

This WP in the Track of theoretical research faces difficult and long-term challenges in terms of deriving the performance limits of Wireless Communications. With respect to similar activities carried out in the past, the focus is "beyond point-to-point": in addition to the classical issues related to the development of capacity-achieving and/or non-binary channel codes for communication links (an area in which NEWCOM# researchers reach absolute world excellence), the WP also tackle more modern problems, like multiuser capacity, capacity of and optimal signal processing techniques for large networks, the achievement of communication security through features of the PHY layer (only), just to mention a few. Particular attention is devoted to issues related to cooperative communications via relays and network modelling, to identify optimal relaying strategies and the relevant ultimate capacity.

The WP is divided into three Tasks, each with specific scope and objectives:

- Task 1.1.1 "Theoretical Limits of Communications and Networks";
- Task 1.1.2 "Relaying and Resource Allocation in Wireless Networks";
- Task 1.1.3 "Capacity-reaching channel codes".

A summary of WP1.1 progress towards objectives

Task 1.1.1 "Theoretical Limits of Communications and Networks"

Task Leader: Romain Couillet (CNRS/Supelec)

- JRA 1.1.1.1: Performance limits of Sparse Bayesian Learning with application to wireless communication systems
  Leader of the JRA: Remy Boyer (CNRS)
  Participating researchers and Institutions: Bernard-Henri Fleury (AAU), Pascal Larzabal and Mohammed Nabil El Korso (CNRS)

Bayesian CRBs have been adapted to the Compressed Sensing problem relying on results from large dimensional random matrix theory to characterize these bounds in simple and interpretable terms.

Standard sparsity-based estimators in case of Compressed Sensing with Basis Mismatch (BM) suffer from a saturated estimation accuracy. This problem has been analyzed within the JRA. Common effort with "Task E" of the WP2.1 have been conducted in order to apply

some new strategies in the framework of CS for propagation channel estimation.

- JRA 1.1.1.2: An Information-Theoretic Perspective of Cooperation and Secrecy in Multi-User Communications
  Leader of the JRA: Pablo Piantanida (CNRS-SUPELEC)
  Participating researchers and Institutions: Meryem Benammar, Mari Kobayashi, Merouane Debbah, Gil Katz and Sheng Yang (CNRS-SUPELEC), Luc Vandendorpe (UCL), Shlomo Shamai (TECHNION)

The importance of a feedback signal in securing wireless communications has been studied from an information-theoretic perspective. Two different approaches are employed in the use of the feedback link: i) an analog approach, ii) a digital approach.

In the analog context, an inner bound of the secrecy capacity has been obtained based on the use of joint source-channel coding. In the digital context, inner and outer bounds have been obtained. For the inner bound, the feedback signal is used to generate a secret key hidden from the eavesdropper. The derivation of an outer bound is for a particular class of channels.

- JRA 1.1.1.3: Communications Performance of Large Dimensional Systems
  Leader: Romain Couillet (CNRS-SUPELEC)
  Participating researchers and Institutions: Pablo Piantanida, Merouane Debbah and Marco Di Renzo (CNRS-SUPELEC), Alessandro Guidotti and Giovanni Emanuele Corazza (CNIT-UniBO), Maxime Guillaud (VUT), Aris Moustakas (IASA)

Among the many research results obtained within this JRA, the Multicast Cognitive Interference Channel (CIFC) has been considered, where many secondary users are interested in the same cognitive message. The role that Multiple Description (MD) coding can play under simultaneous transmissions has been investigated.

A cooperative two-user multi-access channel has been considered in which the transmission is controlled by a random state. Both encoders transmit a common message and, one of the encoders also transmits an individual message. We study the capacity region of this communication model for different degrees of availability of the states at the encoders, causally or strictly causally. The results shed more light on the utility of delayed channel state information for increasing the capacity region of state-dependent cooperative multiaccess channels.

Task 1.1.2 Relaying and Resource Allocation in Wireless Networks
Task Leader: Savo Glisic (UOULU)

- JRA 1.1.2.1: Network Coding schemes for relay channels.
  Leader: Stephan Pfletschinger (CTTC)
  Participating researchers and Institutions: Carmine Vitiello and Marco Luise (CNIT-UniPI), Stephan Pfletschinger and Monica Navarro (CTTC)

The following paper has been accepted and presented (as a collaboration between CTTC and the University of Bremen):

Stephan Pfletschinger, Dirk Wübben, David Gregoratti, “Multi-Carrier Two-Way Relaying with Non-Binary Coding”, 1*0th International Conference on Systems, Communications and Coding (SCC)*, Hamburg, 2-5. Feb. 2015

This activity ended at the second year of N#.

Further research has been conducted in the area of coded slotted ALOHA in collaboration with Giuseppe Cocco from DLR and a journal paper is in preparation.

- JRA 1.1.2.2: Optimization approaches for heterogeneous networks
  Leader: Beatriz Lorenzo and Savo Glisic (UOULU)
  Participating researchers and Institutions: Jordi Perez-Romero, Ramon Agustì (UPC), Luisa Caeiro, Sina Khatibi and Luis M. Correia (INOV)

In the context of heterogeneous Wi-Fi and cellular networks with Multi-Hop capabilities, work has been done on the optimization of the User Equipment (UE) connectivity with the objective of minimizing the total transmit power. A previously proposed distributed solution based on Q-learning has been generalized to consider a network with multiple base stations and in which the UEs acting as Access Points may be operating with the same or with different frequencies. Comparison with centralized approach using genetic algorithms has shown the efficiency of vthe proposed learning technique.

For the activity related to dynamic network architecture (DNA), a new paradigm in wireless network access is considered where certain classes of wireless terminals (PCs or smart phones) can be turned into an AP any time while connected to the Internet. This creates a DNA since the number and location of these APs vary in time. Incitatives to reward UE that turn to AP have been studied to optimize the efficiency of the architecture.

Finally, models for Virtual Radio Resource Management (VRRM) were implemented in Open Air Interface (OAI), *i.e.*, an open-source Linux-based LTE eNodeB, as inter-track activity. Ability of serving multiple groups or VNOs (Virtual Network Operators) was added to OAI. The goal is to evaluate the VRRM model in real LTE emulator. The numeric results were obtained through set of practical scenarios.

- JRA 1.1.2.3: Traffic dynamics - routing and topology reconfiguration
  Leader: Panayotis Mertikopoulos (CNRS)
  Participating researchers and Institutions: Aris L. Moustakas (IASA)

Cooperation between CNRS and IASA has continued on the subject of developing robust multipath algorithms for routing in time-varying infrastructureless wireless networks (typical of mobility scenarios as in the context of MANETs). In this context, we developed a routing algorithm which is asymptotically optimal in hindsight, irrespective of how the network's topology evolves over time; moreover, the algorithm retains its convergence properties even in the presence of noisy latency measurements, a key requirement for deployment in decentralized networks.

A series of research visits has been arranged between CNRS and IASA (P. Mertikopoulos and A. L. Moustakas) to finalize work on this topic and to submit a paper to the IEEE/ACM Transactions on Networking.

The following paper has been accepted for publication:

P. Coucheney, B. Gaujal, and P. Mertikopoulos, "Penalty-regulated dynamics and robust learning procedures in games," Mathematics of Operations Research, DOI: 10.1287/moor.2014.0687., April 2014

The activity of this JRA ended at the second year of N#.

- JRA 1.1.2.4: Applying the information bottleneck method in multi-terminal source coding

Leader: Georg Pichler TU Wien)
Participating researchers and Institutions: Georg Pichler, Gerald Matz (TU Wien), Pablo Piantanida (CNRS/Supelec)

Here, a multi-terminal source coding problem has been considered where two separate encoders observe two dependent memoryless processes X^n and Z^n, respectively. The encoders' goal is to find rate-limited functions $f(X^n)$ and $g(Z^n)$ that maximize asymptotically the mutual information $I(f(X^n);g(Z^n))/n$. Non-trivial inner and outer bounds on the optimal characterization of the achievable rates have been derived for this problem. This type of result may be applied in the context of distributed hypothesis testing against independence under communication constraints.

Task 1.1.3 Capacity-reaching channel codes
Task Leader: Erdal Arikan (Bilkent)

- JRA 1.1.3.1: Spatially Coupled Codes
  Leader: Michael Lentmaier (ULUND)
  Participating researchers and Institutions: Iryna Andriyanova (CNRS), Najeeb ul Hassan (TUD)

During this reporting period, it has been shown that patially coupled codes are very well suited for the block fading channel, the diversity order of the code can be increased, without lowering the code rate, by simply increasing the coupling parameter (memory) of a SC-LDPC code.

Some effort was also done on spatially coupled code design for flexible rates. An altered LDPC ensemble construction has been introduced that changes the evolution of degrees over subsequent incremental redundancy steps in such a way, that the degrees can be kept low to achieve outstanding performance close to Shannon limit for all rates.

- JRA 1.1.3.2: Non Binary Codes
  Leader: Guido Montorsi (CNIT-PoliTO)
  Participating researchers and Institutions: Guido Masera and Muhammad Awais (CNIT-PoliTO), David Declercq and Florence Alberge (CNRS)

A code design optimization has been proposed over the class of irregular LDPC codes compatible with ADBP decoding and obtained performance results improving by 1~dB those obtained by employing the more conventional regular LDPC.

A decoding solution for non binary polar codes based on ADBP has been successfully tested and
validated. The solution offers performance similar to the optimal solution with a complexity that also in this case is independent from the cardinality of the alphabet.

- JRA 1.1.3.3: Coding for Multiterminal Communication Systems
  Leader: Erdal Arikan (BILKENT)
  Participating researchers and Institutions: Shlomo Shamai (TECHNION), Saygun Onay (BILKENT), Pierre Duhamel (CNRS)

The uplink of linear cellular models featuring short range inter-cell interference has been studied. A K-transmitter/K-receiver interference networks has been considered where the transmitters lie on a line and the receivers on a parallel line; each receiver opposite its corresponding transmitter. Upper and lower bounds on the multiplexing gain have been provided for these networks. For certain setups the upper and lower bounds coincide: for

example for the asymmetric network.

Work has also been done on a method that can translate a standard random-coding existence proof to a concrete polar code construction. Standard typical-set proofs rely on a small set of packing and covering lemmas; unfortunately, such lemmas require pairwise independence among codewords and do not apply to polar codes. In this JRA, a first step in relaxing the pairwise independence requirement has been done to prove a form of packing lemma that applies to a generalized form of polar codes.

An intermediate situation between fully orthogonal channels and fully overlapping channels for the Multiple Access Relay Channel (MARC) has been studied. The intent is to study relaying without requiring additional resources, and minimizing the number of nodes involved in the relaying process. The main achievement is to show that this is allowed thanks to the fact that the transmitted signals are protected by some Forward Error Correcting code and using network coding.

Finally, considering the discrete-time intersymbol interference (ISI) channel model, with additive Gaussian noise and fixed i.i.d. inputs, new simple bounds for the achievable rate are proven, and compared to other known bounds.

Highlight of significant results from WP1.1

Inter-track activities

- JRA 1.1.1.1: Standard sparsity-based estimators in case of CS with Basis Mismatch (BM) suffer from a saturated estimation accuracy. This problem has been studied in S. Bernhardt's PhD thesis. Common effort with "Task E" of the WP2.1 has been conducted to apply some new strategies in the framework of CS for propagation channel estimation.
- The concept of virtualization of radio resources has been implemented in Open Air Interface (OAI), i.e., an open-source Linux-based LTE eNodeB, as inter-track activity. In a first step, the ability of serving multiple groups or VNOs (Virtual Network Operators) was added to OAI by means of various modifications especially in the scheduler. Next, codes and algorithms were developed in order to translate the received policies from VRRM model for the scheduler. At last, the VRRM model was integrated with OAI to provide the virtualization of radio resources. As the result, it is now possible to serve multiple VNOs on the same eNodeB in OAI. The goal is to evaluate the VRRM model in real LTE emulator. The numeric results were obtained through set of practical scenarios

N# special sessions

- Special session on *Performance analysis of multi-user communication systems* organized by G. Alfano and M. Kieffer at IEEE EUCNC 2015, Paris.
- Special session on *Advances in Channel Coding* organized by M. Kieffer at IEEE BlackSeaCom 2015, Constanta.

WP1.2: Opportunistic and Cooperative Communications
WP Leader: Sergio Palazzo (CNIT-CT)

This WP addresses the many theoretical aspects related to the various emerging opportunistic and cooperative networking techniques, with the objective of assessing them, and finding the most suited to increase the capacity and/or the availability of wireless networks. In a cellular network scenario, attention is focused on the study of intra-cell relaying among nodes and inter-base station cooperation to achieve significant capacity and multiplexing gain, as

well as to decrease the loss probability, and to improve timeliness in data delivery. In the context of "occasional" and sporadic communications, the WP investigates the techniques for distributed and cooperative resource allocation and routing in delay-tolerant networks, and those for medium access, routing and power-adaptation in Mobile Ad-hoc NETworks (MANETs, also in their special flavour of Mobile Clouds). Special attention is devoted to the study and optimization of cooperative sensing in unstructured networks.

A summary of WP1.2 progress towards objectives

The WP is divided into three Tasks, each with specific scope and objectives:

- Task 1.2.1 "Cooperative multi-user communication";
- Task 1.2.2 "Optimal design of opportunistic networks and mobile clouds";
- Task 1.2.3 "Cooperative sensing".

During the third year, a new JRA has been activated, and three JRAs have been declared as closed. Thus, in the third year the WP 1.2 has been hosting 11 JRAs whose activities carried out in the reporting period are described in detail in the Deliverable D1.2.3.

Task 1.2.1 Cooperative multi-user communication
Task Leader: Ivan Stupia (UCL)

- JRA 1.2.1-1 on information-theoretic perspective of cooperation in multi-user communications
  Participating researchers and Institutions: M. Benammar (SUPELEC-CNRS), P. Piantanida (SUPELEC-CNRS) and S. Shamai (Technion)

In the third year research activities have been focused on information theoretic analysis of wireless opportunistic communications.
Specifically, coding/decoding processes, capacity bounds and availability of channel information state have been analyzed and studied to provide theoretical bounds and analytical results.
As a result, several joint and individual papers have been published.

- JRA 1.2.1-2 on Network coding for MARC
  Participating researchers and Institutions: M. El Soussi (UCL), A. Zaidi (CNRS- Université Paris-Est Marne-La-Vallée), and L. Vandendorpe (UCL)

This JRA was declared as closed at the end of the second year.

- JRA 1.2.1-3 on Message-passing methods for distributed wireless network organization
  Participating researchers and Institutions: Mihai-Alin Badiu (AAU), Maxime Guillaud (VUT), Bernard Fleury (AAU)

This JRA was declared as closed at the end of the second year.
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- JRA 1.2.1-4 on Distributed learning schemes for interference management and signal optimization in large networks
  Participating researchers and Institutions: P. Mertikopoulos (CNRS), E. V. Belmega (CNRS), S. D'Oro (CNIT-CT), A. L. Moustakas (IASA), S. Palazzo (CNIT-CT)

In the third year, research activities focused on interference-based pricing schemes for opportunistic multi-carrier cognitive radio systems, the development of distributed learning algorithms for efficient and robust covariance matrix optimization in multiple-input-multiple-output

(MIMO) multiple access channels, and the robust maximization of energy efficiency in dynamic MIMO-OFDM networks. During the reporting period, several joint journal and conference papers have been published.

- JRA 1.2.1-5 on Clusters organization for multi-hop cooperative communications
  Participating researchers and Institutions: S. Mijovic (CNIT/UniBO), C. Buratti (CNIT/UniBO), A. Zanella (CNIT/UniBO), I. Stupia (UCL), R. Andreotti (CNIT/UniPI), V. Lottici (CNIT/UniPI), and F. Giannetti (CNIT/UniPI)

This JRA considers Wireless Sensor Networks (WSNs), where nodes form Virtual Antenna Arrays (VAAs) and use cooperative beamforming to transmit toward a sink. During the reporting period, research activities focused on the study of tradeoffs between the improvement of the link capacity due to cooperation and the energy used to form the VAAs. This tradeoff has been analyzed by formulating the VAA formation problem as a noncooperative game with complete information. Based on this game theoretical model, a communication protocol for VAA formation was proposed.

- JRA 1.2.1-6 on Synchronization Error in Cooperative Wireless Sensor
  Participating researchers and Institutions: Stefan Mijovic, Chiara Buratti, Roberto Verdone (CNIT/UniBO), Luca Sanguinetti (CNIT/UniPi-CNRS/Supelec), Merouane Debbah (CNRS/Supelec)

In this JRA cooperative Multiple-Input-Multiple-Output (MIMO) scheme for Wireless Sensor Networks (WSN) have been studied.
The performance of a perfectly synchronized system in order to understand the benefits of cooperation has been analyzed by considering the MIMO asymptotic regime. As a result, the optimal number of sensor nodes to be deployed and the duration of the channel estimation phase have been derived.
During the reporting period, a joint paper has been published in an international conference.

Task 1.2.2 Optimal design of opportunistic networks and mobile clouds
Task Leader: Laura Galluccio (CNIT-CT)

- JRA 1.2.2-1 on Opportunistic relaying and forwarding
  Participating researchers and Institutions: L. Galluccio (CNIT-CT), B. Lorenzo (UOULU/University of Vigo), S. Glisic (UOULU), C. Buratti (CNIT-BO), C. Giannini (CNIT-BO), R. Verdone (CNIT-BO)

This JRA dealt with the investigation of dynamics of opportunistic relaying and forwarding in delay tolerant networks. In particular, this activity started with the definition of a model of information dissemination in delay tolerant networks. Then the activity prosecuted with the consideration of how social relationships among users impact on the opportunistic dissemination of information and was finally extended in with the use of real human mobility traces collected at the last EuCNC 2014 incorporated into the mathematical framework. During the reporting period, several joint journal and conference papers have been published.

- JRA 1.2.2-2 on Game theoretic approach to timing channel communications
  Participating researchers and Institutions: Salvatore D'Oro, Laura Galluccio and Giacomo Morabito (CNIT-CT), Fabio Martignon and Lin Chen (CNRS)

This JRA was focused on the completion of the research activities involving game theory and jammed timing channels, already started in the previous years. The JRA has reached its target through the publication of a joint journal paper.

Task 1.2.3 Cooperative sensing
Task Leader: Aris L. Moustakas (IASA)

- JRA 1.2.3-1 on Multiple source detection, localization, and transmit power
  Participating researchers and Institutions: G. Arvanitakis (EURECOM), A. Polydoros (IASA), F. Kaltenberger (EURECOM), A. Kliks (PUT)

This JRA dealt with the performance evaluation of passive RSS based transmitter localization and power estimation via distributed sensor networks, and has involved theoretical as well as experimental research. The theoretical part strictly belongs to this JRA and the experimental part to JRA 2.1.3.F on ``Design and experimental validation of algorithms for active and passive indoor positioning'' and JRA 2.3.3.1 on ``Localization with Distributed Antennas''. As a result of the research activities, two joint conference papers have been published.

- JRA 1.2.3-2 on Cooperative simultaneous localization and tracking
  Participating researchers and Institutions: F. Meyer (VUT), B. Cakmak, B. H. Fleury (AAU), Franz Hlawatsch (VUT).

This JRA exploits a recently developed theoretical framework to compare belief propagation and mean-field approximation approaches and possibly combine them for distributed localization in cooperative networks.
A distributed controller that moves the nodes of the network in a way that is favorable for the estimation task performed for cooperative localization has been developed.
Also, distributed algorithms that jointly estimate the locations and clock parameters of mobile network nodes in a fully distributed fashion have been designed.
During the reporting period, several joint conference and journal papers have been published.

- JRA 1.2.3-3 Source detection in the presence of interference and noise
  Participating researchers and Institutions: Aris Moustakas, Spyridon Evangelatos (IASA), Erwin Riegler (TUV)

In this JRA, the performance of message passing in the detection of the state of operation of multiple primary sources from a network of secondary users in the context of large-scale heterogeneous networks is analyzed. A method to analyze and quantitatively predict, for a given environment, what is the region in the parameter space of the system, such as density of SUs and primary sources, signal to noise ratio for the power, where the detection of the active sources is adequate as been proposed. Research activities led to the preparation of a joint journal paper which is still under review.

- JRA 1.2.3-4 on Hybrid spectrum sensing architecture for cognitive radio: overcoming noise uncertainty
  Participating researchers and Institutions: Amor Nafkha and Malek Naoues (CNRS/Supelec), Adrian Kliks and Krzysztof Cichon (PUT)

The purpose of this JRA was to develop and implement an hybrid spectrum sensing structure in order to overcome the noise uncertainty and reduce sensing time. The hybrid spectrum sensing architecture is composed of a double threshold sequential energy detector (SED) followed by a cyclostationarity-based detection called Symmetry Property of Cyclic Autocorrelation Function (SPCAF). The efficiency of the proposed architecture has been verified experimentally using USRP N210 boards under GNURadio environment.
The JRA also proposed to investigate the performance and complexity of sensing methods based on the eigenvalues of the received covariance matrix.
As a result, several joint papers have been published.

- JRA 1.2.3-5 on Energy-efficient data collection and estimation in wireless sensor networks
  Participating researchers and Institutions: M. Kieffer, F. Bassi, W. Li (CNRS-UniPS), D. Dardari, V. Zambianchi, G. Pasolini (CNIT-UniBo), S. Fosson, E. Magli (CNIT-PoliTo), J. Matamoros, C. Anton-Haro (CTTC)

This is a cross WP JRA between WPs 1.2 and 1.3. The efforts during the third year were on the design and theoretical analysis of in-network reconstruction techniques of jointly sparse signals. In particular, a novel distributed iterative thresholding for the case where sensor signals share a common support and, a distributed Alternating Direction Method of Multipliers (ADMM) for the jointly sparse signals with innovations have been proposed.
During the reporting period, several joint conference and journal papers have been published.

Highlight of significant results from WP1.2

During the third year the WP1.2 activities have been profitably finalized. In particular, the research activities carried out by partners in JRAs led to the publication of numerous papers in conferences and journals. More specifically, here we provide the list of the journal papers that satisfy all the three following conditions:

- they have been already published or accepted for publication in the Reporting Period (November 2014 - October 2015),
- they contains explicit acknowledgements to NEWCOM#,
- they are co-authored by researchers belonging to more than one NEWCOM# partners.

The main conference EuCNC hosted some NEWCOM# Special Sessions. Specifically, in the Special Session on "Opportunistic and cooperative communications", organized by S. Palazzo (CNIT/CT), the following contributions from WP1.2 have been presented:

- "Cost-effective power allocation and throughput optimization in cognitive radio networks", by S. D'Oro (CNIT-CT), P. Mertikopoulos (IMAG), A. Moustakas (IASA), S. Palazzo (CNIT-CT)
- "Adaptive infection recovery in opportunistic scenarios: a realistic model obtained from experimental traces", by L. Galluccio (CNIT-CT), B. Lorenzo (Un. Vigo), S. Glisic (Un. Oulu), C. Buratti (CNIT-BO), C. Giannini (CNIT-BO)
- "Distributed reconstruction of jointly sparse signals with innovation via ADMM", by J. Matamoros (CTTC), S. Fosson (CNIT-TO), E. Magli (CNIT-TO), C. Anton-Haro (CTTC)
- "Received power-based multisource localization in correlated log-normal fading environment", by I. Dagres (IASA), G. Arvanitakis (Eurecom), F. Kaltenberger (Eurecom), A. Kliks (PUT), A. Polydoros (IASA)
- "Experimental study on cyclostationary feature and eigenvalue based algorithms for spectrum sensing", by A. Nafkha (Supelec), B. Aziz (Supelec), M. Naoues (CEA-LETI), A. Kliks (PUT)

WP 1.3 Energy- and Bandwidth-Efficient Communications and Networking

WP Leader: Andreas Polydoros (IASA)

The objective of this WP is to investigate techniques at different layers which result in power- and energy- efficient networks and nodes. This also encompasses interference management (control/mitigation) techniques for coexisting networks and modern wireless network topologies such as multi-tier and Heterogeneous Networks (HetNets). Based on the participants'

interests and expertise the WP is divided into three Tasks, each with specific scope and objectives.

- Task 1.3.1 “Techniques for power-efficient communications” deals with techniques for power efficiency and minimization at the transceiver and network level.
- Task 1.3.2 “Low-interference, low-emission, radio interfaces” deals with the handling of interference by appropriate low interference transmission techniques (e.g. beamforming, MIMO, GMC).
- Task 1.3.3 “Resource Allocation for optimized radio access”: is about Radio Resource Management (RRM) and Interference Management (IM) – for a given interference level – in selected scenarios, including HetNets and multi-tier networks.

In each Task, the work is organized in Joint Research Activities (JRAs) in order to enhance cooperation between partners and promote research harmonization. JRA 1.3.3B on “Game-theoretic energy-efficient control and resource allocation algorithms in heterogeneous networks” completed the activities at the end of the second year of the project.

A summary of WP1.3 progress towards objectives

IASA as the WP leader, worked for the harmonization of the various research efforts and for the preparation of the D13.3 deliverable – the final version was submitted in October 2015. D13.3 targets to highlight the main achievements of each JRA and to provide information on the produced results. There is a summary section where for each JRA there is a description of the activity, an illustration of the adherence and relevance with the identified fundamental open issues and a short presentation of the main results. The main technical details of selected achievements from the JRAs are reported in the Annex I of D13.3. A summary of these achievements per Task is given below:

Task 1.3.1: Techniques for power-efficient communications
Task leader: Jesus Gomez (CTTC)

In this task the objective is the development of techniques and algorithms for the optimization of energy efficient communications either from the terminal or from a network point of view. Concentrated at the physical layer, the focus was on the use of energy harvesting power sources, data collection exploration, estimation and communication techniques. At the MAC and Network layers the work concentrated at the proposed protocol channel decoding techniques and the energy efficiency of considering the MAC layer jointly with the physical layer.

- JRA 1.3.1A on resource allocation and scheduling strategies for energy harvesting devices
  Leader: Javier Rubio (UPC)
  Participating researchers and Institutions: Javier Rubio (UPC), Maria Gregori (CTTC), Miquel Payaró (CTTC), and Antonio Pascual-Iserte (UPC)

For the scenario of simultaneous information and power transfer in multiuser MIMO networks, development of management strategies for the harvest of the energy.
Resource allocation strategies for the uplink considering backhaul constraints.

- JRA 1.3.1B on energy-efficient data collection and estimation in wireless sensor networks
  Leader: Francesca Bassi (CNRS/UPS)
  Participating researchers and Institutions: Michel Kieffer, Francesca Bassi, Wenjie Li (CNRS-UniPS), Davide Dardari, Vincenzo Zambianchi, Alex Callisti, Gianni Pasolini (CNIT-UniBo), Sophie Fosson, Enrico Magli (CNIT-PoliTo), Javier Matamoros, Carles Anton-Haro (CTTC).

CNIT/TO and CTTC have provided a number of in-network reconstruction techniques for different jointly sparse models: a distributed iterative thresholding technique for common support detection that merely exchange 1-bit messages; a distributed ADMM-based reconstruction method for in-network reconstruction of jointly sparse signals with innovations.
CNIT-UniBo and CNRS-UniPS have proposed and analyzed two low-complexity Distributed Outlier Detection (DOD) techniques. Only local information exchange with neighbours is necessary. In the first technique, decision is only taken after a given number of measurements have been taken and exchanged between nodes. In the second approach, a decision is taken after each measurement and exchange of information with neighbours. Theoretical performance has been verified both in simulation and on the EuWin platform at Bologna. During the second visit of W. Li at CNIT-UniBo, experiments have shown the importance and limiting aspects of the MAC layer on the performance of the proposed algorithms. Future investigations will consider these issues.
CNIT-UniBo and CNRS-UniPS have provided a distributed implementation of the Sign-Perturbed-Sum technique for non-asymptotic confidence region characterization of a multi-dimensional parameter observed at different network nodes under a linear measurement model. The distributed SPS algorithm is well-suited to WSN, for in-node evaluation of the confidence regions. The performance is evaluated in terms of required traffic load, both analytically and numerically. The best information exchange strategy among nodes depends on the structure of the network. Theoretical performance has been verified on the EuWin platform at Bologna.

- JRA 1.3.1C on Joint Protocol Channel Decoding (JPCD)
  Leader: Michel Kieffer (CNRS)
  Participating researchers and Institutions: P. Duhamel CNRS, M. Kieffer CNRS/UniPS, M. Chiani, E. Paolini, M. Mazzotti CNIT/UniBo.

Identification of pilot bits to help channel decoding at PHY layer. The proposed technique is able to determine pilot bits from previously received packets, without having to scrutinize the upper protocol layers, which largely broadens the applicability of the approach.
Reliable identification of packet type before performing channel decoding. This approach has been exploited in the robust packet type determination of ROHC-compressed packets.

- JRA 1.3.1D on energy efficient probing in CSMA based multi-rate ad hoc networks - Leader: Mehmet Koseoglu (BILKENT), Researchers involved: Mehmet Koseoglu (BILKENT), Ezhan Karasan (BILKENT), Lin Chen (UPS)

Development of a cross-layer energy-efficient method for underwater networks employing random access which significantly improved the energy efficiency of an underwater network by jointly selecting the MAC layer access rate along with the PHY-layer transmission power. As recharging of underwater nodes is difficult, the proposed method improves the lifetime of an underwater network.

Task 1.3.2: Low-interference, low-emission, radio interfaces
Task Leader: Adrian Kliks (PUT)

This task deals with the proposal of novel solutions for the efficient use of resources in future wireless communication systems. In the context of 5G networks, these advanced resource utilization schemes have to consider the phenomena of interference induction to the neighboring systems. The research activities within this task are covered by two JRAs: the first considers the problem of energy-efficient communications, whereas the second deals with the issues of non-linearities in the multicarrier systems. The main achievements are listed below.

- JRA 1.3.2A on advanced MIMO techniques (virtual MIMO, MIMO-FBMC) for low-interference transmission
  Leader: Adrian Kliks (PUT)
  Participating researchers and Institutions: Adrian Kliks, Paweł Kryszkiewicz, Hanna Bogucka (PUT), Màrius Caus, Ana I. Pérez Neira (CTTC, UPC), Carla Oliveira, Luis Correia (INOV), Marco Moretti (UniPi), Carlos Bader, Quentin Bodinier (Centrale-Supelec)

Continuation of work on MIMO-FBMC systems in the context of detailed system capacity derivation as a function of the selected pulse shape: the frequency domain approach has been studied where real and imaginary parts are treated separately, and the approach considering the improper nature of the used pulses.

- JRA 1.3.2B on advanced filtering and adaptive signal processing (OOB, PAPR, SIC) - Leader: Pawel Kryszkiewicz (PUT)
  Participating researchers and Institutions: Adrian Kliks, Paweł Kryszkiewicz, Hanna Bogucka (PUT), Yves Louet (CNRS/SUPELEC)

The main effort within this JRA in the last year was put on the derivations on the PAPR distribution in the non-contiguous multicarrier schemes, in particular focusing on NC-OFDM. Significant progress has been achieved in this area – first a journal paper has been submitted on PAPR upper bounds for NC-OFDM transmission schemes. Moreover, a theoretical work on PA linearization in USRP board (inter-WP activity) was done and the results of the carried-out experiments have been presented at ISWCS'2015 (Brussels, Belgium).

Task 1.3.3: Resource Allocation for optimized radio access
Task Leader: Luca Sanguinetti (CNIT)

This Task is focused on energy-efficient algorithmic solutions for the management of resources and interference in wireless networks. The Task consists of three active JRAs – JRA 1.3.3B on "Game-theoretic energy-efficient control and resource allocation algorithms in heterogeneous networks" completed the activities at the end of the second year of the project. The main achievements are listed below.

- JRA 1.3.3A on interference management techniques for heterogeneous networks
  Leader: Jordi Pérez-Romero (UPC)
  Participating researchers and Institutions: Jordi Pérez-Romero, Katerina Koutlia, Ramon Agusti, Abdelrahman Abdelkader (UPC), Andreas Zalonis, Andreas Polydoros (IASA), Adrian Kliks, Paweł Kryszkiewicz, Hanna Bogucka (PUT), Lila Boukhatem, Steven Martin, Tara Ali Yahia, Reben Kurda (UniPS)

A comprehensive framework for how Radio Environmental Maps (REMs) can be used for interference management has been proposed. It includes a layered REM architecture for a 3GPP LTE network with tight integration of WLAN. Different interference management techniques have been assessed both quantitatively and qualitatively in the context of this framework, including practical and architectural implications.
A new eICIC algorithm for managing ABS subframes has been proposed that jointly exploits the time, frequency and power dimensions.
The results of the measurement campaign carried out in WP2.1 (JRA#G) to characterize the TV White Space (TVWS) availability in indoor locations have been used as input of an optimization strategy that decides the positions and transmit powers of indoor small cells, so that no harmful interference is generated to digital TV receivers.

- JRA 1.3.3C on self-configuration and optimization of a hybrid LTE Femto - M2M network for smart city applications
  Leader: Danilo Abrignani (CNIT-UniBo)

Participating Researchers and Institutions: Danilo Abrignani, UniBo, Lorenza Giupponi, CTTC, Roberto Verdone, UniBo

Implementation of carrier aggregation on the ns3 LENA simulator.

- JRA 1.3.3D on Radio resource allocation algorithms in cognitive radio networks with outdated CSI
  Leader: Filippo Giannetti (CNIT-Pisa)
  Participating Researchers and Institutions: Riccardo Andreotti (CNIT-Pisa), Paolo Del Fiorentino (CNIT-Pisa), Filippo Giannetti (CNIT-Pisa), Vincenzo Lottici (CNIT-Pisa), Marc Moeneclaey (UGent), Jeroen Van Hecke (UGent)

Development of a distributed resource allocation and a path selection strategy for cognitive radio multi-hop scenario with decode-and-forward relay nodes and OFDM modulation, considering imperfect channel state information.
An optimal symbol energy allocation and beamforming scheme are derived to minimize the outage probability in a CR scenario, where a secondary transmitter transmits a signal to the secondary receiver through a single carrier, exploiting an infrastructure of fixed multi-antenna amplify-and-forward relay nodes.
Practical implementation on USRP platforms of an IEEE 802.11 WiFi transmission system with the aim to a practical implementation of some algorithms derived during WP 1.3 activities. The aim is to evaluate resource allocation algorithms for OFDM in a real-time over-the-air transmission that is a definitely cross-track activity involving track 1 and track 2.

Highlight of significant results from WP1.3

In this WP, as part of Track 1 of Newcom# project, the research work is concentrated on the algorithmic development of the various WP-relevant solutions. The outcomes of these efforts are disseminated through scientific publications and are reported in D13.3 deliverable. In most cases, although the work is theoretical, practical issues are taken into account by appropriate modelling of the uncertainties of the real world. In order to better investigate the practical implementation of the proposed solutions, various JRAs established a connection to Track 2 activities.

In Task 1.3.1 there was a significant number of activities targeting in the development of techniques and algorithms for the optimization of energy efficient communications either from the terminal or from a network point of view. At the physical layer, the use of energy harvesting devices and the existence of removable energy sources in have been taken into consideration. The research work resulted in a large number of publications that are listed in D13.3 and in the previous deliverables. New advanced estimation strategies for the particular scenario of Wireless Sensors Network have been developed by putting especial emphasis in the energy consumption optimization. The proposed algorithms and techniques techniques were analyzed, their performance was theoretically assessed and, at the end, this performance was verified both through simulation and with the EuWin platform at Bologna. The recently proposed protocol channel decoding techniques, also referred to as Joint Source-Channel Decoding (JSCD) was investigated with the target to improve the energy efficiency of receivers by improving the synchronization and the channel decoding techniques, and thus, avoiding wasting energy due to packet retransmissions. Finally, the energy efficiency of the CSMA protocol was analyzed, as most of the MAC protocols for power-constrained devices employ non-persistent CSMA. The goal was to develop an energy efficiency model which can be applicable for CSMA-based standards in general. That effort led to the development of a cross-layer energy-efficient method for underwater networks employing random access which significantly improved the energy efficiency of an underwater network by jointly selecting the MAC layer access rate along with the PHY-layer transmission power.

Task 1.3.2 focus on the handling of interference by appropriate low interference transmission techniques. More specifically, the detailed analysis of the FBMC system capacity has been investigated and the closed form formulas have been derived. The main contribution of this work was the implication that the self-interference that is inherent to FBMC systems, due to overlapping of pulses in time and frequency domains, can be utilized as useful part of the received power. The proposed formulas show that there exists a relation between the capacity and the used pulses for data transmission – one can try to maximize the capacity by the proper selection of the transmit and receive pulse pair. Such result is of high importance in the context of future wireless communications systems, since FBMC scheme (or its variations) is considered for application in the near future. It is also worth noticing that both SISO and SIMO cases have been analyzed. In terms of the future work, the development of appropriate precoders that will simplify the utilization of the existing interference is highly expected. Moreover, the analysis of the Carrier Frequency Offset on the FBMC system is envisaged. In the second JRA of Task 1.3.2 the main focus was on the derivation of the Peak-to-Average Power Ratio (PAPR) and Out-of-Band Emission (OOBE) metrics for the Non-Contiguous (NC) multicarrier schemes, mainly concentrating on the NC-OFDM scheme. In the context of coexistence of multiple users in the same geographical vicinity the application of non-contiguous schemes can lead to better spectrum utilization. One can imagine for example such illustrative situation where Program Making and Special Events (PMSE) device, such as wireless microphone, occupies the narrow frequency band for data delivery. Then, the secondary user could utilize the unused spectrum on both sides of the signal spectrum. In that context the incumbent transmission cannot be distorted, thus it is highly necessary to limit the level of OOBE and minimize the energy observed out of the nominal signal band. Although the above example is related mainly to cognitive radio, it can easily by transferred to advanced radio resource management schemes, where the non-contiguous spectrum could be assigned to the users of the same priority due to, e.g., current channel conditions. Thus, the analysis of PAPR and OOBE is crucial in that situation. The theoretical analysis has been supported by experiments carried out within Track 2. The proposed techniques have been verified using USRP board and the achieved results proved that it is practically possible to achieve – at relatively low price – high OOBE attenuation. Thus, the main message that can be extracted from this experiment is that NC-OFDM scheme can be applied in future wireless systems leading for better spectrum utilization.

Task 1.3.3 is concentrated in Radio Resource Management and Interference Management techniques, in selected scenarios, including HetNets and multi-tier networks. A significant result was the development of a comprehensive framework for how Radio Environmental Maps (REMs) can be used for interference management in a 3GPP-LTE network with tight integration of WLAN. Different interference management techniques have been assessed both quantitatively and qualitatively in the context of this framework, including practical and architectural implications. Furthermore, a novel eICIC algorithm for managing ABS subframes has been proposed that jointly exploits the time, frequency and power dimensions. There was also a collaboration with Track 2, where the results of the measurement campaign carried out in WP2.1 (JRA#G) to characterize the TV White Space (TVWS) availability in indoor locations have been used as input of an optimization strategy that decides the positions and transmit powers of indoor small cells, so that no harmful interference is generated to digital TV receivers. The use of imperfect channel state information was also investigated in the development of new resource allocation algorithms. The produced results are described in the deliverable D13.3 and are expected to lead to new publications after the end of the project. Furthermore, work towards practical implementation of the developed algorithms has been initiated and more results are expected in the near future.

There was also a significant number of dissemination activities in the last year of the project. Some selected activities are listed below:

- Kliks (PUT), J. Pérez-Romero (UPC), L. Boukhatem (UniPS), A. Zalonis (IASA), were the editors of the special issue entitled "Technical Advances in the Design and Deployment of Future Heterogeneous Networks" in EURASIP Journal on Wireless Communications and Networking. The editors prepared the following editorial article: A. Kliks (PUT), J. Pérez-Romero (UPC), L. Boukhatem (UniPS), A. Zalonis (IASA) "Technical Advances in the Design and Deployment of Future Heterogeneous Networks", EURASIP Journal on Wireless Communications and Networking, June, 2015.
- The tutorial “Emerging topics in small-cell networks: evolution towards 5G solutions”, by A. Kliks (PUT) and J. Pérez-Romero (UPC) was held in EuCNC 2015, Paris, France, June 29, 2015.
- Luca Sanguinetti (JRA 1.3.3B) was invited in April 2015 to Linkoping University (Sweden) to give a seminar on the design of wireless networks for maximal energy-efficiency.
- The second Newcom# workshop was held in January 2015 in Athens, Greece, organized by IASA. In this workshop the WP1.3 JRAs presented the current status of the research work. On January 22, 2015 a WP1.3 meeting was held in Athens, organized by IASA as the WP leader.

2.2.2 TRACK 2

Track Leader: Roberto Verdone (CNIT)

Track 2 is devoted to the “EUropean laboratory of WIreless communications for the future INternet” (EuWIn) that hosts researchers from within the network, from external Academic Institutions, and from European companies. EuWIn is organized as a collaborative effort of the constellation of all NEWCOM# partners orbiting around three different reference sites at three different NEWCOM# Institutions. Through its activity on themes like Radio Interfaces, Internet of Things, and Flexible Communication Terminals and Networks, the Lab allows the experimental verification of some of the results produced in Track 1. The hosting Institutions of the three EuWIn nodes offers facilities and personnel to host researchers performing the different cooperative research actions described later on in the Joint Program of Activities. EuWIn has the ambition of creating a permanent environment for cooperative research that survives the NoE with the contribution of the hosting Institutions.

WP 2.1 Radio interfaces for next-generation wireless systems

WP Leader: Miquel Payaro (CTTC)

This Work Package is devoted to set up, operate, and maintain the EuWIn facilities at the Centre Tecnològic de Telecomunicacions de Catalunya (EuWIN@CTTC). The general focus is on the implementation of radio interfaces with emphasis on low energy consumption, low emission, and high spectral efficiency, as well as on localization techniques in wireless communication terminals. In order to assess the performance of these radio interfaces in close-to-real-world situations, a set of realistic channel models is also developed within this WP.

The WP is divided into five Tasks, each with specific scope and objectives:

- Task 2.1.1 “Lab set-up maintenance and planning”;
- Task 2.1.2 “Low-energy-consumption and low-emission radio interfaces”;
- Task 2.1.3 “Hybrid localization techniques for wireless terminals”;
- Task 2.1.4 “High spectrally-efficient radio interfaces”;
- Task 2.1.5 “Channel measurements, modelling and databases”.

The lab is open to all NEWCOM# partners for the possible implementation, experimental validation and performance assessment of research results from Track 1, especially Task 1.1.1 “Theoretical limits of communications and networks”, Task 1.1.3 “Capacity-reaching channel codes”, Task 1.3.1 “Techniques for ultra-power-efficient terminals”, and Task 1.3.2 “Low-interference, low-emission, radio interfaces”. Part of the results in this implementation-oriented WP is also fed back into the theory-oriented WPs in Track 1, so that the theoretical models and results can be further refined taking into account practical constraints.

In order to foster industry-academia cooperation, WP2.1 organizes activities such as lab visits and/or virtual tours to its premises. Besides, it reports on lab activities and results at some of the in-company dissemination events organized by NEWCOM#. Where appropriate, WP2.1 stimulates NEWCOM#’s Affiliate Partners (or other companies’) participation in its activities.

A summary of WP2.1 progress towards objectives and highlight of technical results

During the first year, this WP established a clear structure in terms of Tasks and Task leaders, and the different Joint Research Activities (JRAs) consolidated and started proper operation in the vast majority of cases. In the second year, researchers enjoyed fruitful collaboration and made relevant progress in their activities. In this third (and last) year, researchers have consolidated the obtained results and, additionally, a ninth JRA has also been created.

Hereafter, we report as usual a list of the most relevant outcomes from the work performed within the different tasks and JRAs, summarizing their activity with a focus (where possible) in this third year.

Task 2.1.1 Lab set-up maintenance and planning
Task Leader: Miquel Payaró (CTTC)

The lab set-up activity was completed during the second quarter of the project. The description of the lab set-up was reported in deliverable D21.1 “Description of EuWIn@CTTC technical facilities and interfaces, and preliminary plan of activities.” In addition, D21.1 included the description of the interfaces through which the assets of EuWIn@CTTC can be accessed.

Beyond May 1st, 2013 the main activity related to this task was devoted to performing small lab maintenance duties.

Task 2.1.2 Low-energy-consumption and low-emission radio interfaces
Task Leader: Amor Nafkha (Supelec)

- JRA#A Enhanced NC-OFDM transmission with reduced spurious emission level
  Participating Researchers and Institutions: Paweł Kryszkiewicz (PUT), Adrian Kliks (PUT), Amor Nafkha (SUPELEC), Malek Naoues (SUPELEC).

It was managed to measure nonlinearity characteristics of USRP frontend. It has been used by memoryless predistortion that significantly reduced nonlinear distortion of NC-OFDM transmitter. This predistortion has been combined with NC-OFDM spectrum shaping method (developed within WP 1.3) and reported in paper accepted for ISWCS 2015.

Task 2.1.3 Hybrid localization techniques for wireless terminals
Task Leader: Carles Fernández-Prades (CTTC)

- JRA#F Design and experimental validation of algorithms for active and passive indoor positioning
  Participating Researchers and Institutions: Sinan Gezici, Bilkent University, Davide Dardari, Giacomo Calanchi CNIT Bologna, Luc Vandendorpe, Université catholique de Louvain, Carles Fernández-Prades, Pau Closas, Javier Arribas, Ana Moragrega, Juan Manuel Castro Arbizu, CTTC, External researchers: Héctor Torres (Universidad Tecnológica Metropolitana – Chile)

As a wrap-up of the research activities developed within this JRA, a testbed of indoor positioning techniques has been developed. It consists of a mobile robotic platform equipped with different air interfaces (WiFi, Bluetooth, Zigbee) and an onboard computer implementing the different algorithms for indoor positioning. This allows repeatable trajectories and fair comparison between different approaches.

Task 2.1.4 High spectrally-efficient radio interfaces
Task Leader: Guido Masera (CNIT)

- JRA#B Practical implementation of polar codes
  Participating Researchers and Institutions: Andrea D. G. Biroli and Guido Masera, CNIT (Politecnico di Torino), Erdal Arıkan, Bilkent University, Luis Blanco, Centre Tecnològic Telecomunicacions Catalunya.

Two main outcomes were achieved in this JRA:
1) From the cooperation with Bilkent University, a Belief Propagation based decoder has been designed, which offers higher throughput than previous decoders implementing the Successive Cancellation algorithms. The activity is complete and a journal paper has been submitted.
2) A novel predictive successive cancellation decoding scheme has been studied, which reduces latency at high signal to noise ratios. The activity end with some work towards a VHDL synthesizable model.

- JRA#H Impact of channel model in the performance evaluation of wireless systems
  Participating Researchers and Institutions: Nikolaos Bartzoudis, Oriol Font-Bach, Miquel Payaró (CTTC), Claude Oestges, Evgenii Vinogradov (UCL).

Within the GEDOMIS testbed, an experimental performance evaluation of a communication scenario that features spectrum sharing capabilities and the use of post-OFDM modulations has been carried out. The experimental lab set-up was assembled so as to operate in conditions as realistic as possible via the actual real-time implementation of the involved transceivers and also via the utilization of propagation channels which have been recorded in a field measurement campaign and which are loaded in a channel emulator that also operates in real-time (via collaboration with UCL). The results of this activity have been accepted for publication the PIMRC'15 conference proceedings.

Task 2.1.5 Channel measurements, modelling and databases
Task Leader: Troels Pedersen (AAU)

- JRA#C Assessment and development of multi-link channel models
  Participating Researchers and Institutions: Evgenii Vinogradov (UCL), Claude Oestges (UCL), Wout Joseph (UGent), Brecht Hanssens (UGent), Vittorio Degli-Esposti (CNIT-UNIBO), Enrico Vitucci (CNIT-UNIBO), Thomas Zemen (FTW), Mingming Gan (FTW).

Regarding the development of indoor multi-link channel models (UCL, UGgent), the first model (from UCL) was combined with room-electromagnetic theory (from UGent) to include late components. A joint UCL-UGent experimental campaign was carried out in February 2015 to estimate the channel dynamics in various indoor environments. A joint paper was presented at EuCAP 2015, and a journal paper is in preparation.

- JRA#D Channel models for cooperative positioning
  - Troels Pedersen, Gerhard Steinböck, Morten L. Jakobsen, Bernard H. Fleury (AAU), Ronald Raulefs, Wei Wang (DLR), Bernard Uguen (Uni. Rennes I)

A channel model for the purpose of link-level simulation of ranging in wide-band channels was developed. This model, which is based on Turin's channel model, has been applied in the derivation and test of approximate MAP and MMSE ranging with unknown LOS state. A paper has been published at the ICC-ANLN workshop, and a journal paper is in preparation.

- JRA#E Compressive sensing for sparse propagation channel estimation
  Participating Researchers and Institutions: R. Boyer (CNRS/UPS), J.P. Barbot, P. Larzabal, M. N. El Korso, T. NGuyen (CNRS/SATIE), B. Fleury, T. Pedersen (Aalborg University)

A sparse model of the Complex Impulse Responses (CIR) had been introduced. Then, a l0-optimization had been performed and two algorithm tested: the “Iterative Hard Thresholding” (IHT) algorithm and the recently proposed CELO algorithm. The resulting analysis will be presented in a contribution to the “CAMSAP” conference.

- JRA#G Spectrum occupation measurements and database exploitation
  Participating Researchers and Institutions: Adrian Kliks, Paweł Kryszkiewicz, Poznan University of Technology, Jordi Pérez-Romero, Anna Umbert, Ferran Casadevall, Universitat Politècnica de Catalunya

1) Regarding the work on indoor REM creation for TVWS, we have implemented a Kriging algorithm to interpolate measurements.
2) The indoor measurement results have been used as input to an algorithm that optimizes the position and transmit power of a number of small cells to be deployed inside the building, acting as secondary transmitters, ensuring that no interference is generated to TV users. (link with WP1.3)

- JRA# I: Hybrid radio channel modeling using graphs and rays
  Participating Researchers and Institutions: Troels Pedersen, Gerhard Steinböck (AAU), Mingming Gan, Thomas Zemen (FTW), Paul Meissner (TU Graz), Erik Leitinger (TU Graz), Klaus Witrisal (TU Graz)

For in-room reverberant channels ray-tracing with propagation graphs were combined to obtain a simplified, less computationally intensive hybrid model. Preliminary results and final results were submitted as a technical document and presented at the meetings of COST IC1004 on May 26th to 28th 2014 and May 5th to 7th 2015 and the final results have been submitted to IEEE Transactions on Antennas and Propagation (joint publication AAU and FTW).

Highlight of significant non-technical results from WP2.1

Concerning joint research activities, the main achievement of WP2.1 has been the participation in the Joint NEWCOM/COST Workshop on Wireless Communications (JNCW 2015) held in Barcelona on October 14-15, 2015 (see http://www.newcom-

project.eu/index.php?option=com_content&view=article&id=159&Itemid=210). The event was a success with more than 70 persons attending. The workshop was the perfect occasion to present the outcomes and final results of the JRAs in WP21 via oral and poster demonstrations and also via two demos:

1. GNSS-SDR: a software-defined, satellite-based navigation receiver
2. Spectrum sharing scenario via 5G (candidate) waveforms

The objective set in the Y2 review meeting targeting the activity for year 3 of having a significant amount of inter-track JRAs has been met. Precisely, the following JRAs of WP2.1 are inter-track:

- Enhanced NC-OFDM transmission with reduced spurious emission level (JRA#A)
- Practical implementation of polar codes (JRA#B)
- Spectrum occupation measurements and database exploitation (JRA#G)
- Impact of channel model in the performance evaluation of wireless systems (JRA#H)

EuWin@CTTC has incubated an open source project implementing a Global Navigation Satellite Systems (GNSS) receiver, freely available at http://gnss-sdr.org. Along the past three years, the project has achieved some significant milestones (e.g., be the first open source receiver to obtain position fixes using uniquely satellites from the Galileo constellation), attracting the interest from industry and academia, getting involved in projects, and becoming a reference for software-defined GNSS receivers.

EuWIn had already proved during the previous years to be able to attract interest of major companies towards the experimental facilities of the three sites. This was confirmed during the third year. However, during the third year it was also proved that EuWIn labs are effective in offering services to SMEs. Regarding EuWIn@CTTC (WP2.1) researchers involved in the GEDOMIS facility of EuWIn are preparing a joint proposal for H2020 with the Spanish SME, Signadyne.

The PhD student Paolo Del Fiorentino from CNIT/Pisa was granted a Newcom# travel grant to carry out a one-month secondment at EuWIn@CTTC. Paolo will be involved in the practical implementation of a resource allocation algorithm for an OFDM-based transceiver in the USRP N210 platform that EuWIn@CTTC makes available.

The EuWIn@CTTC site participates in the COST Action IRACON that has been submitted as a potential framework for the continuation of the Newcom community joint research activities.

Organization of a Special Session on “European platforms and facilities for experimentation towards 5G”, in the European Conference on Networks and Communications, held in Paris, France, from June 29th to July 2nd, 2015. The Special Session was on Monday, June 29th, and was chaired by Dr. Miquel Payaró (CTTC, Spain). The list of presented papers represents a showcase of the joint research activities performed in the framework of EuWIn and also the presence of two large companies is to be highlighted:

- Ericsson's 5G Vision, Hugo M. Tullberg (Ericsson Research, Sweden)
- Virtualizing the Network Edge with Microservers, Filipe Manco and Kenichi Yasukata (NEC Europe Ltd., Germany), João Martins (NEC Europe Ltd, Germany), Felipe Huici (NEC Europe Ltd., Germany)
- A Broadcast-Based Routing Protocol for Linear Wireless Networks: Design and Testing on EuWIn, Chiara Buratti (University of Bologna, Italy), Andrea Stajkic (DEI, University of Bologna, Italy), Roberto Verdone and Parisa Hemmati (University of Bologna, Italy)
- OpenAirInterface: Open-source software radio solutions for 5G, Florian Kaltenberger (Eurecom, France), Raymond Knopp (Eurecom, France), Navid Ni-

kaein (Eurecom, France), Dominique Nussbaum (Eurecom, France), Lionel Gauthier (Eurecom, France), Christian Bonnet (Eurecom, France)

- o End-to-end 5G services via an SDN/NFV-based multi-tenant network and cloud testbed, Raul Muñoz (CTTC, Spain), Josep Mangues-Bafalluy (CTTC, Spain), Nikolaos Bartzoudis, Ricard Vilalta (CTTC, Spain), Ricardo Martinez (CTTC, Spain), Ramon Casellas (CTTC, Spain), Nicola Baldo (CTTC, Spain), José Núñez-Martínez (CTTC, Spain), Manuel Requena-Esteso (CTTC, Spain), Oriol Font-Bach (CTTC, Spain), Marco Miozzo (CTTC, Spain), Pol Henarejos (CTTC, Spain), Ana Pérez-Neira (CTTC, Spain), Miquel Payaró (CTTC, Spain)

Spreading results activities, especially towards the industry

- o On February 26 th, a delegation of Newcom# researchers participated in an Industry Dissemination Event at the premises of Telecom Italia (TI) in Turin (Italy). The event consisted in a series of presentations by both Newcom# and TI researchers followed by rounds of discussions among them. The main goal of this event was to give an overview of the Newcom# project and to disseminate the activities and obtained results within the Newcom# frame to TI researchers. In particular, there was one talk related to WP2.1 activities "Radio Interfaces for Energy Efficiency and Interference Management" which was given by M. Payaró.
- o On May 4th, a delegation of Newcom# researchers participated in an Industry Dissemination Event at the premises of Ericsson AB (EAB) in Kista, Stockholm (Sweden). The event consisted in a series of presentations by both Newcom# and EAB researchers followed by rounds of discussions among them. The main goal of this event was to give an overview of the Newcom# project and to disseminate the activities and obtained results within the Newcom# frame to EAB researchers. In particular, there were two talks related to WP2.1 activities which were given by M. Payaró and were entitled "FBMC-Related Experimental Activities at EuWIn@CTTC".
- o Testbed for Experime

WP 2.2 Networking technologies for the Internet of Things (IoT) with mobile clouds
WP Leader: Davide Dardari (CNIT)

This Work Package aimed at setting up, operating, and maintaining the EuWIn facility at the University of Bologna (EuWIN@CNIT/Bologna). The general focus is on networking technologies for the Internet of Things (IoT) with mobile clouds, with particular emphasis in Smart City as well as indoor applications. The lab was open to all NEWCOM# partners for the implementation, experimental validation and performance assessment of research results from Track 1.

The WP is divided into three Tasks, each with specific scope and objectives:

- ➢ Task 2.2.1 "Lab set-up, maintenance and planning";
- ➢ Task 2.2.2 "Large-scale wireless sensor networks: routing protocols, network topologies and cooperative localization";
- ➢ Task 2.2.3 "Experimental Activities on Opportunistic Networks with Mobile Clouds";

A summary of WP2.2 progress towards objectives

The activity of the last year has been mainly concentrated in finalizing the experimental campaign using the EuWin@CNIT-BO platforms to validate theoretical results obtained in Track 1. A particular effort has been devoted to demonstration activities, meetings with industries, workshops, and to the organization of training schools dedicated to experimental research.

These dissemination activities are described in Deliverable D22.4 Annex II. Starting from this dissemination campaign, collaboration with companies willing to exploit the capabilities of the EuWIn platform for experimental research has been established, as detailed in Deliverable D22.4.

Task 2.2.1 Lab set-up, maintenance and planning
Task leader: Danilo Abrignani (CNIT-BO)

This task is mainly related to platforms maintenance and testing of the 3 different platforms designed and deployed at EuWin@CNIT-BO during the first 2 years. These platforms offer more than 200 wireless nodes implementing different types of radio interfaces: Flexible Topology Testbed (FLEXTOP), Data Sensing and Processing Testbed (DATASENS), and Localization Testbed (LOCTEST). In the third year the following improvements have been carried out at EuWin@CNIT-BO:

- Increased number of devices in FLEXTOP (now more than 50)
- Validation of Lab facilities with updated over-the-air software
- Integration between OpenInLocation EUWin@CTTC and EuWin@CNIT/BO
- Finalization and test of a low-cost IEEE 802.11.4a ultra-wideband localization platform in LOCTEST.

Task 2.2.2 Large-scale wireless sensor networks: routing protocols, network topologies and cooperative localization
Task leader: Chiara Buratti (CNIT-BO)

Two JRAs have been consolidated, covering all the topics addressed by the Task and using the available facilities. JRA#3 is the experimental counterpart of theoretical JRAs in Track1 and hosted the algorithms developed there.

- JRA#1 Design and experimental validation of algorithms for active and passive indoor positioning
  Leader: Davide Dardari (CNIT-BO)
  Persons (institutions) involved: Pau Closas (CTTC), Carles Fernandez (CTTC), Sinan Gezici (Bilkent), Luc Vanderdorpe (UCL), Achraf Mallat (UCL), Petar Djuric (Stony Brook Univ.)

Both EuWIn@CNIT-BO and EuWIn@CTTC provide experimental platforms for indoor localisation. For this reason, JRA#1 has been set up to integrate software tools, and to achieve a common open source platform for indoor localisation. In the third year the indoor localization platform, developed with EuWIn@CTTC and integrated in LOCTEST at EuWin@CNIT-BO site, has been used to test crowd sensing/mapping algorithms. Specifically, an experimental campaign involving a high accuracy positioning system and a mobile sensor took place at CNIT-BO to validate an efficient statistical method for characterizing spatial physical fields. Results have shown the effectiveness of the crowd mapping approach in real environments.

- JRA#3 Experimental activity on data sensing and fusion
  Leader: Gianni Pasolini (CNIT-BO)
  Participating Researchers and Institutions: Alex Calisti (CNIT-BO), Francesca Bassi (CNRS-SUPELEC), Michel Kieffer (CNRS-SUPELEC), Davide Dardari (CNIT-BO), Vincenzo Zambianchi (CNIT-BO)

This JRA is active on two separate sub-lines:

- The impact of the protocol stack and of real propagation conditions on the performance of a low complexity distributed fault detection algorithm for large WSNs, proposed in Track 1, has been investigated using the experimental facilities available at EuWIn@CNIT/Bologna. To this purpose a research exchange from Supelec/Univ. Paris Sud to CNIT-BO took place in June/July 2015.
- A test bed composed of 70 DATASENS nodes deployed in a real environment has been set up to validate the analytical results obtained in Task 1.2.3 on distributed algorithms for efficient information diffusion in WSNs. In particular, the effects of MAC protocol and random network topologies have been investigated. This activity has been carried out within the inter-track JRA "Experimental activity on data sensing and fusion" which involves CNRS/Univ. Paris Sud and CNIT-BO.

- *JRA#4, "Reducing Traffic Congestion in Wireless Mesh Networks"*: This JRA is not active anymore and could be considered as closed.
- JRA#5, "Socially-aware protocols for wireless mesh networks"
  Leader: Laura Galluccio (CNIT-CT)
  Participating Researchers and Institutions: Chiara Buratti (CNIT-BO), Colian Giannini (CNIT-BO), Roberto Verdone (CNIT-BO)

This JRA started during the second year where CNIT-BO worked on the inter-track JRA about “Opportunistic relaying and forwarding” with CNIT-CT and OULU. A first contribution has been presented at EUCNC 2015 Conference, during the Newcom# special Session. During the EUCNC Conference the DATASENS Demo performed during EUCNC 2014 has been repeated. During the demo up to 50 people carried 802.15.4 devices and the inter-contact time was measured and characterized.

Task 2.2.3 Experimental Activities on Opportunistic Networks with Mobile Clouds
Task Leader: Danilo Abrignani (CNIT-BO) (former: H. Saarnisaari (OULU))

So far one JRA has produced significant results in this Task during the third year.

- JRA#6 Testing IP-based Wireless Sensor Networks for the Internet of Things
  Leader: Danilo Abrignani (CNIT-BO)
  Participating Researchers and Institutions: Andrea Stajkic (CNIT-BO), Stefan Mijovic (CNIT-BO), Chiara Buratti (CNIT-BO), Roberto Verdone (CNIT-BO), Sebastiano Milardo (CNIT-CT), Giacomo Morabito (CNIT-CT), Gordana Gardasevic (University of Banja Luka)

CNIT-BO and CNIT-CT were involved in this JRA on testing multi-hop protocols for smart city applications. New measurements have been done on FLEXTOP in order to characterize the performance of Sigsbee and SDWN in the presence of dynamic environments. The results have been included in several papers one of which accepted for publication on the IEEE Internet of Things Journal.

Highlight of significant results from WP2.2

The main achievements of the WP during the third year of Newcom# can be summarized as follows:

- Final integration of the ultra-wideband localization platform using IEEE 802.11.4a devices into the LOCTEST platform at EuWin@CNIT-BO.

- Finalization of the experimental research within the joint research activities (JRAs) carried out using the EuWIn@CNIT-BO platforms. Some JRAs were inter-WP and inter-Track. The former were oriented to increase the integration between the distributed EuWIn laboratories. The latter demonstrated the utility of EuWIn for the experimental validation of theoretical schemes investigated in Track 1 in real scenarios. In particular, among the active JRAs, JRA#1 dealt with localization issues and mainly used the LOCTEST platform; JRA#3 was related to efficient and distributed fault detection and information diffusion techniques for wireless sensor networks and it exploited the DATASENS facility. Finally, multi-hop routing protocols and topologies have been studied and tested in JRA#5 and JRA#6 using FLEXTOP.

- Establishment of activities developed in collaboration with industries outside the network of excellence NEWCOM#. In particular, after the meeting held on April 15 between CNIT-BO and Cefla Group, CNIT-BO started working on testing smart building applications on the FLEXTOP platform. People from WP22 participated to the NEWCOM# Dissemination Events at Ericsson, Telefonica and Telecom Italia premises. After the last dissemination event, on March 27 2015, five Engineers from Telecom Italia visited the EuWIn site in Bologna. During the meeting all the activities carried out by UniBO in the framework of Flextop, Datasens, and Loctest were presented. Two actions were taken: establishment of a collaboration finalised to open a PhD position at UniBO fully funded for three years by Telecom Italia, for research to be performed in the context of IoT at EuWIn@UniBO; start of a discussion finalised to the possible duplication of the EuWIn FLEXTOP testbed at the premises of Telecom Italia Future Centre in Venice; this action is still on going.

- Dissemination activities in the form of papers, workshops, tutorials and other events (described in Annex II of Deliverable D22.4). Two joint publications won the 2014 Newcom# best paper award assigned during the EuCNC 2015 conference in Paris.

- EuWIn Bologna has been included in the COST Action Proposal OC-2015-1-19350 on "Inclusive Radio Communication Networks for 5G and beyond".

WP 2.3 Flexible communication terminals and networks
WP Leader: Raymond Knopp (Eurecom)

A summary of WP 2.3 progreess towards objectives

The WP is divided into three Tasks, each with specific scope and objectives:

- Task 2.3.1 “Lab set-up maintenance and planning”;
- Task 2.3.2 “Task 2.3.2 Tools for embedded hardware/ software architectures”;
- Task 2.3.3 “Task 2.3.3 Experimentation in collaborative communication in multi-hop network topologies”.

In general, the workpackage is very active with 6 active JRAs (and one dormant JRAs).

Several joint papers were produced and some papers are in the pipeline. Moreover, the OpenAirInterface platform, which is the core product of the EuWin@EURECOM lab is gaining significant attention, both within the network and outside (academic and industry).

OpenAirInterface currently provides a standard-compliant implementation under a GNU GPLv3 license of a subset of Release 10 LTE for UE, eNB, MME, HSS, SGw and PGw on standard Linux-based computing equipment (Intel x86 PC architectures). It can be used in

conjunction with standard RF laboratory equipment available in many labs (i.e. National Instruments/Ettus USRP and PXIe platforms) in addition to custom RF hardware provided by EURECOM to implement these functions to a sufficient degree to allow for real-time interoperation with commercial devices. Some industrial users have working OpenAirInterface-based systems integrated with commercially-deployable remote radio-head equipment and have provided demonstrations at major industrial tradeshows (Mobile World Congress Asia 2014, Mobile World Congress Barcelona in 2013, IMIC 2013). The current major industrial users of OpenAirInterface for collaborative projects are Agilent, China Mobile, IBM, Alcatel-Lucent, Thales, National Instruments and Orange. The primary future objective is to provide an open-source reference implementation which follows the 3GPP standardization process starting from Rel-12 and the evolutionary path towards 5G and that is freely-available for experimentation on commodity laboratory equipment.

The output of this WP2.3 will help extend OpenAirInterface to help towards the definition of 5G systems. In particular the open-source policy will hopefully help to drive innovation in 5G by following the standard as it is being drafted and to leverage the crowdsourcing effect both from industrial and academic users. To this end, the JRAs #1 (cloud RAN), #3 (4G/5G coexistence), and #7 (exploiting TDD reciprocity) are a first step in this direction. The resulting development can be used in both publicly-funded collaborative projects as well as industry-driven initiatives aiming to demonstrate 5G features at the earliest possible stage. Moreover, the results can be replicated in several locations independently through the combination of open-source and commodity hardware. This then becomes a truly distributed experimental facility with a very large number of potential contributors.

Task 2.3.1 Lab set up, maintenance and planning
Task Leader: Eurecom

- JRA#4 OAI Lab setup for joint teaching activities.
  Leader: IASA
  Institutions involved: IASA, Eurecom

Task 2.3.2 Tools for embedded hardware/ software architectures
Task Leader: Eurecom

- JRA#1a Cloud RAN (platform).
  Leader: EURECOM
  Institutions involved: CNIT-Polito, Bilkent

Task 2.3.3 Experimentation in collaborative communication in multi-hop network topologies
Task Leader: Eurecom

- JRA#2 Cellular Broadcasting.
  Leader: CNRS-Supelec
  Institutions involved: EURECOM, KCL, CNRS-Supelec, Ucam
- JRA#3 Experimental Analysis of 4G/5G coexistence.
  Leader: EURECOM
  Institutions involved: TUD, EURECOM, CNIT-Pisa
- JRA#5 Multihop coding for networks.
  Leader: IASA
  Institutions involved: EURECOM, IASA
- JRA#6 Localization with Distributed Antennas
  Leader: EURECOM

Institutions involved: IASA, EURECOM

- JRA#7 Exploiting Channel Reciprocity in MIMO TDD channels
  Leader: EURECOM
  Institutions involved: VUT, EURECOM

Task 2.3.4 Large-scale emulation for the Internet of Things (IoT)
Task Leader: Eurecom

- JRA#1a Cloud RAN (Architecture).
  Leader: EURECOM
  Institutions involved: INOV, EURECOM

Highlight of significant results from WP2.3

- A batch of 30 new ExpressMIMO2 cards was delivered to EURECOM. Several cards were further sold to partners from outside the network.
- In terms of JRAs, the most active ones were
  - JRA#1 on cloud RAN, which produced 2 joint papers and lead to the integration EURECOM/Inov work on CRAN transport mechanisms in OAI.
  - JRA#3 on 4G/5G coexistence, which resulted in a joint experiment between Eurecom and TUD and a paper at EuCNC 2015 in Paris. Further joint work with CNIT (UniPisa) on integration of UFMC into OpenAirInterface was started and first results were shown at the final Newcom# workshop in Barcelona.
  - JRA#6 on localization, where measurements collected with OpenAirInterface were exploited. These results were published in two papers at EuCNC 2015in Paris.
  - JRA#7 on exploiting channel reciprocity, which produced also 1 paper at ICC 2015.
- WP2.3 showed a strong presence at EUCNC Paris with an exhibition booth showing for the OpenAirInterface eNB communicating with an off-the-shelf UE (smartphone) and 4 papers and presentations with Newcom acknowledgement
- OAI's LTE basestation software and ExpressMIMO2 were demonstrated at the Mobile World Congress in Barcelona (Feb. 24-27 2015). Parts of OAI software was also successfully demonstrated by China Mobile and Keysight as an enabling technology for CloudRAN at the same event.
- Presentation of WP2.3 JRAs and OAI demonstrations at dissemination events (Ericsson Stockholm)
- Presentation on *Open-Source for 5G* by OAI team at the NGMN (Next Generation Mobile Networks) association 5G ICE event in Frankfurt, 24-25 March 2015.
- A research visit from Carmine Vitiello from CNIT-Pisa to Eurecom lead to the implementation of UFMC/UF-OFDM into the OpenAirInterface platform. This work was also presented to Alcatel-Lucent Bell Labs Stuttgart (Germany) and received positive feedback. This action also lead to the university of Pisa joining the OpenAirInterface 5G software alliance and thus means that this project will be continued within this framework.
- OpenAirInterface software is used by more and more people both from industry and academia. It is also used in several of the recently started 5G-PPP projects, such as Coherent, SELFNET, Flex5Gware, SESAME, FANTASTIC 5G.
- Creation of the OAI Software Alliance and development of the OAI Public License in conjunction with four confirmed strategic members ALU Bell Labs, Orange, TCL and Ercom. Current discussions with other major industry players for strategic membership with a target of ten for end 2016. Many confirmed associate members UniPisa, B-COM, iMinds, UniMalaga, University of Kent, Ruhr University Bochum, Beijing University of Posts and Telecommunications, Chinese Academy of Sciences, University of Washington, University of Utah, IIID India, Rutgers-WINLAB (under negotiation), TNO Holland (under negotiation), Fraunhofer IIS/Fokus (under negotiation).

2.2.3 TRACK 3

Track Leader: Luis Correia (INOV)

The third track, in addition to the activities on training, human capital, and dissemination in the research community that is detailed later on, pays special attention to relations with European companies that participate to the NoE life as "Affiliate Partners", with the right to take part into events and technical meetings, and with the commitment of organizing and participating into periodic dissemination events in different countries. Some companies became Affiliates of NEWCOM# at the proposal phase of the project, others during this first year of activity.

WP 3.1 NEWCOM# Conferences, Workshops and Special Sessions

WP Leader: Claude Oestges (UCL)

Dissemination of research results produced within the NoE starts of course from the organization of dedicated events and from the participation in the major scientific events of the international research community. As a consequence, the main objectives of this work-package are the following:

- Organize an annual NEWCOM# conference with peer review and proceedings (in the second and third year).
- Interface with other EC projects and events and exploit possible synergies with the Future Network and Mobile Summit, concertation events, etc.
- Promote the involvement of NEWCOM# in the organization of major, already existing international conferences and workshops.
- Organize special sessions within the framework of NEWCOM# during major international conferences on the subject of wireless communications and related issues.

A summary of WP3.1 progress towards objectives

Task 3.1.1 NEWCOM# annual conference and final event

Task Leader: Roberto Verdone (CNIT)

In June 2015, the second NEWCOM# annual conference was successfully held in Paris (France) in conjunction with EuCNC 2015, with one tutorial, three technical sessions and one exhibition stand.

The NEWCOM# Final Conference, also known as the Joint NEWCOM/COST Workshop on Wireless Communications (JNCW 2015), was held in Barcelona, Spain, on October 14-15, 2015, in conjunction with former COST IC1004 **(**Cooperative Radio Communications for Green Smart Environments). Participation and paper submission was open to anyone, member or not of these Actions. The event included one opening plenary, two invited talks, two technical sessions covering Tracks 1 and 2, one poster and demo session, one SME event and two joint technical workshop sessions.

Task 3.1.2 EC concertation activities

Task Leader: Jossy Sayir (UCAM)

NEWCOM# was represented in the NetTech Future Concertation Meeting by CTTC. Two upcoming training and dissemination events, namely, the Emerging Topic Workshop on "Device-to-Device (D2D) and millimetre wave Communications" (Vienna University of Technology, 27-28 October 2014) and the Training School on "Mathematical Foundations of Future Wireless Networks" (Politecnico di Torino, 19-21 November 2014) were properly announced

to the audience. A number of NEWCOM# activities in the field of cognitive radio were brought to the attention of the keynote speaker, this including the involvement of project researchers in activities related with the ACROPOLIS measurement campaign in downtown London. NEWCOM#'s EUWIN lab was also introduced in a presentation of the Networld2020's White Paper entitled “Towards 5G: an Experimental Perspective”.

Finally, Jossy Sayir (UCAM) and Luis Correia (INOV) attended the concertation meeting scheduled Wednesday, 25 March from 9 to 12 on the fringes of the “NetFutures 2015” event in Brussels (http://netfutures2015.eu).

NEWCOM# was also involved in the organization of EuCNC 2015. Besides the fact that NEWCOM# held its annual conference in conjunction with EuCNC, many of its members were part of the conference committees (Steering Committee and Technical Program Committee).

Task 3.1.3 Conference workshops and special sessions
Task Leader: Giacomo Bacci (CNIT)

A total of 4 workshops were organized, in conjunction with international conferences:

- Second Workshop on Cognitive Radio Advances, Applications and Future Emerging Technologies (CRAFT) @ ISWCS 2014,
- Workshop on Advances in Network Localization and Navigation (ANLN) @ ICC 2015,
- Workshop on Dependable Vehicular Communications (DVC) @ ICC 2015,
- Third Workshop on Cognitive Radio Advances, Applications and Future Emerging Technologies (CRAFT) @ ISWCS 2015.

Highlight of significant results from WP3.1

The final event, which attracted more than 90 attendees, truly gave the NEWCOM# community the opportunity to disseminate their research results, after 3-4 years of activity within the framework of the European FP7 research program.

WP 3.2 Education and Training

WP Leader: Gerald Matz (VUT)

Three Seasonal Schools, one Training Session, and an Emerging Topics Workshop have been organized in year 3 of NEWCOM#. The Seasonal Schools typically lasted for several days and consisted of short-courses and tutorials on advanced topics in wireless communications. These courses were given by leading experts from within and outside NEWCOM#. One of the (more theory-oriented) seasonal schools was co-organized with a practical hands-on training session at EuWIn@Eurecom.
The Emerging Topic Workshop (ETW) in year 3 was dedicated to Advances in Coding and Information Theory. It was meant to foster the exchange of ideas regarding new trends in coding and to provide a platform for PhD students to identify practically relevant and scientifically challenging topics. For most of the events, a detailed summary including course material and presentation slides are available at the Euracon website (www.euracon.org). This has the advantage that the pertinent material is also available to the non-NEWCOM# public.

A summary of WP3.2 progress towards objectives

Task 3.2.1 Seasonal Schools
Task Leader: Roberto Verdone (CNIT)

During the third year of NEWCOM#, two Summer Schools and one Winter School have been organized by NEWCOM# researchers. The details of these events are as follows:

Winter School (25 attendees)
Title: MAthematical Foundations of Future wIreless Networks (MAFFIN)
Organizer: Giusi Alfano (PoliTo)
Chairs: Guido Montorsi (PoliTo), Riccardo Zecchina (PoliTo)
Date: Nov. 19-21, 2014
Venue: Politecnico di Torino, Italy
Link: http://www.euracon.org/maffin2014

Summer School (37 attendees)
Title: Foundations and Advances in Stochastic Filtering (FASF 2015)
Organizer: Pau Closas (CTTC)
Chairs: Petar M. Djurić (Stony Brook University, USA), Jordi Vilà-Valls & Carles Fernández Prades (CTTC, Spain), Kari Heine (Univesity College London, UK), Omiros Papaspiliopoulos (ICREA/Universitat Pompeu Fabra, Spain), Thomas Schön (Uppsala University, Sweden).
Date: 22-26 June, 2015
Venue: CTTC, Castelldefels (Barcelona), Spain
Link: http://fasf2015.cttc.cat

Summer School (17 attendees)
Title: Waveforms and Network Architectures for the IoT in 5G (WaveNAT)
Organizer: Raymond Knopp (Eurecom)
Chairs: Florian Kaltenberger (Eurecom), Roberto Verdone (CNIT/UniBo)
Date: Sept. 14-16, 2015
Venue: Eurecom, Sophia Antipolis, France
Link: http://www.euracon.org/asphen2014

Task 3.2.2 EuWIn Training Sessions
Task Leader: Sylvain Azarian (Supelec)

A training session was held in Sept. 2015 in conjunction with the WaveNAT summer school at Eurecom in Sophia Antipolis (France).

Task 3.2.3 Emerging Topics Workshops
Task Leader: Miquel Payaro (CTTC)

Third Emerging Topics Workshop (32 attendees)
Title: Advances in Coding and Information Theory
Chairs: Jossy Sayir (UCAM)
Venue: University of Cambridge, UK
Date: June 25-26, 2015

All events attracted a sizeable number of attendees (with a slight decline towards the end of Y3 that can be explained by the fact that the project approached completion) and have been a huge success with the participants due to the high quality of the technical programs. All

WP3.2 milestones during year 3 have been achieved.

Highlight of significant results from WP3.2

The NEWCOM# events have had increasing industry outreach, e.g., 7 of the 17 participants at the last EuWIn Training Session came from European industry (Huawei France, Alcatel Lucent, etc.) and 3 of the 6 lecturers at the WaveNAT summer school were industry representatives (Cisco, Alcatel Lucent, Intel). The combination of a Summer School with a Training Session at EuWIn@Eurecom provided an excellent opportunity to promote interaction of the experimental activities in Track 2 of NEWCOM# with the theoretical work in Track 1.

WP 3.3 Journal special issues, books and book chapters
WP Leader: Luc Vandendorpe (UCL)

In NEWCOM#, WP3.3 deals with «Journal special issues, books and book chapters». These tools have been identified as possible instruments to disseminate the research results produced by NEWCOM# researchers, as well as to increase the recognition of the network within the related international research community. The objectives of this WP3.3 are therefore as follows:

- To foster the design and implementation of Journal Special Issues in international peer reviewed journals, dealing with the main research topics addressed in NEWCOM#.
- To stimulate the participation of NEWCOM# researchers as prospective authors in the journal special issues organised either by NEWCOM# or by third parties.
- To trigger and organise the writing of book chapters and books. Book chapters will be devoted to the state-of-the-art and the recent advances of specific scientific and technological topics addressed by NEWCOM# researchers while books will be reserved for the results of Track 1 of the project.

A summary of WP3.3 progress towards objectives

Task 3.3.1 Identification of topics for SIs, book chapters, books, journals, and monitoring of CfPs.
Task Leader: Luca Vandendorpe (UCL)

The first activity of the WP was the creation of the list and the description of journals (EURASIP, IEEE and others) which are of interest for special issues organized by NEWCOM# researchers, or to which NEWCOM# could contribute. A list of main book and book chapters publishers (e.g. Wiley, Springer, Cambridge University Press, etc.) was also created with the cooperation of which NEWCOM# authors could disseminate their production. Finally, a preliminary list of topics that have been identified as potential topics for special issues to be launched by NEWCOM# members as well as the associated WP/tasks was edited as well. Workpackage and task leaders have been regularly contacted to take initiative and have discussion in their respective WP/task in order to identify new topics or new opportunities for dissemination

Task 3.3.2 Organization of SIs and writing of books and book chapters.
Task Leader: Claude Oesteges (UCL)

Researchers from within the NoE (spontaneously or after appropriate solicitation actions by the Task leader) took an active role in proposing and organizing special issues on journals, taking the initiative to publish books containing the results of the JRAs, both as a self-

standing volume or as contributions to multi-author books. Being aware that journals may be subject to different formatting rules and editorial restrictions, the following *acknowledging* strategies and statements have been suggested:

- To explicitly mention NEWCOM# in the text of the corresponding Call for Papers.
- To insert the NEWCOM# logo on the cover of the journal special issue.
- To explicitly mention NEWCOM# in the title of the special issue (e.g. 'NEWCOM# Special Issue on…').
- To include a sentence in the guest editorial such as '*This special issue has been supported by the European Network of Excellence NEWCOM#*'.
- To point out in the guest editorial that (part of) of the team of guest editors are involved in NEWCOM#.

Explicitly mention NEWCOM# in the guest editorial has been the most used acknowledgement formula.

Currently, a total of 8 journal special issues, 2 books and 5 book chapters have been launched.

The Journal Special Issues originated by NEWCOM# activities published or launched so far are as follows:

- *Enabling 5G: Energy and Spectral Efficient Communication Systems*, Transactions on Emerging Telecommunications Technologies (John Wiley);
- *Indoor Localization, Tracking, and Mapping with Heterogeneous Technology*, IEEE Transactions on Vehicular Technologies;
- *Machine-to-Machine: An Emerging Communication Paradigm*, published in the Transactions on Emerging Telecommunications Technologies;
- *Special Issue on Signal Processing Techniques for Anywhere, Anytime Positioning*, published in the EURASIP Journal on Advances in Signal Processing ;
- *JCN Special Issue on Advances in Channel* Coding to be published in the Journal of Communications and Networks;
- *Special Issue on Technical advances in the design and deployment of future heterogeneous networks* to be published in the EURASIP Journal on Wireless Communications and Networking.
- *Context-Aware Communications and Networking – An important paradigm for 5G networks* to be published in Wireless Personal Communications (SPRINGER).
- *Experimental Evaluation in Wireless Communications,* EURASIP Journal on Wireless Communications and Networking.

The published books are as follows:

- *Machine-to-Machine (M2M) Communications, Architecture, Performance and Applications*, Woodhead Publishing Ltd.
- *Opportunistic Spectrum Sharing and White Space Access: The Practical Reality* will be published by Wiley.

The following book chapters have been written by NEWCOM# members:

- "*Null-space precoder for dense 4G and beyond networks*" included in the book entitled *Resource Allocation and MIMO for 4G and Beyond,* Springer ;
- "*Future challenges in efficiently supporting M2M in the long term evolution (LTE) standards*", in "Machine-to-Machine (M2M) Communications, Architecture, Performance and Applications." Woodhead Publishing ;

- "*An introduction to M2M*", in "Machine-to-Machine (M2M) Communications, Architecture, Performance and Applications." Woodhead Publishing.
- "*Aggregation of spectrum opportunities*", in "Opportunistic Spectrum Sharing and White Space Access: The Practical Reality." Wiley.
- "*OpenAirInterface and ExpressMIMO2 for spectrally agile communication*", in "Opportunistic Spectrum Sharing and White Space Access: The Practical Reality." Wiley.

This task also includes the edition of NEWCOM# White Book (in electronic format) which will summarize the main scientific outcomes of the project along with a number of open issues to be addressed in the years to come.

Task 3.3.3 Promotion activities
Task Leader: Adrian Kliks (PUT)

Activities aimed at adequately publicizing these Special Issues both within and outside the NEWCOM# community: to maintain e-mail reflectors, to ensure the widest possible circulation of the corresponding call for papers through e-mail reflectors, etc. One page of the NEWCOM# website, called "Journal special issus" is devoted and maintained with the related information (link to Call for Papers, editors, etc ..). The address of this page is: http://www.newcom-project.eu/index.php?option=com_content&view=article&id=17&Itemid=110

Furthermore, NEWCOM# inspired JSIs has been announced by means of:

- Portals and websites,
  - NEWCOM# portal (http://www.newcom-project.eu).
  - Society webpages (e.g. http://www.signalprocessingsociety.org).
  - Publisher's or journal webpages.
  - Personal webpages.
- Newsletters,
  - NEWCOM# newsletter.
  - Societies' Newsletters.
- Mailing lists.
  - Mailing lists run by various IEEE technical committees.
  - COST2100 mailing list.
  - Personal mailing lists.
  - NEWCOM# mailing lists.

Besides, paper copies of the CFPs have been distributed in various conferences and workshops where guest editors regularly participate in the months preceding the submission deadline.

Highlight of significant results from WP3.3

To date, a total of eight JSIs, five book chapters and two books inspired by NEWCOM# joint research activities have been implemented.

As far as the addressed topics are concerned, 4G and 5G cellular communications and machine-to-machine communications are the most popular topics. Localization and positioning also had a prominent role in NEWCOM#. Moreover, innovative subjects like context-aware communications have been approached, without neglecting advances in more traditional topics like channel coding.

A detailed analysis on the activities carried out within WP3.3 indicates that the average number of guest editors in the special issues launched so far is 3.87 with a 55% coming from NEWCOM# institutions. Thus, NEWCOM# institutions played a key role to keep the focus on the topics addressed within the network of excellence. The effort of the entire network of excellence in disseminating the achievements of the N# joint research activities is further testified by the fact that all the work packages have been involved in the launch of JSI, books and book chapters.

Non-European institutions have been involved in launching of JSIs, books and BCs: two of them are located in the US and one in Asia. Concerning the collaboration with other EC-founded project, it is worth mentioning the book entitled *Opportunistic Spectrum Sharing and White Space Access: The Practical Reality*, which is the result of a joint effort between NEWCOM# and ACORN members.

JSIs, Books and BCs were publicised via various means, namely, Journals' webpage, the NEWCOM# webpage, the NEWCOM# Newsletter, distribution through the mailing lists of the guest editors.

WP 3.4 Industry Liaison and Dissemination

WP Leader: Hikmet Sari (Supelec)

One of the main objectives of NEWCOM# is to improve dissemination of the research results produced by the NoE towards the European wireless communications industry. The general aim of the activity is to support and possibly drive to some extent the research performed at companies to help them innovate and maintain a strong position in the international competition. Dissemination is mainly carried out by organizing periodic dissemination events hosted by Affiliate Partners from industry. The rationale is that organization of such events at the premises of the Affiliates facilitates participation of their engineers, managers, and other employees without incurring any significant travel cost. Also, the dissemination events are advertised and are open especially to companies in the same country as the hosting Affiliate to maximize participation by reducing traveling costs. By organizing a sufficiently large number of events (2 in the first year, up to 4 in the second and third year) most countries and regions in Europe are covered. During the events, the Host and other interested Institutions are requested to highlight their needs and expectations in terms of R&D to possibly find a match of interests with the (mainly) academic research performed by NEWCOM#, and the NoE presents its experimental facilities at EuWIn to possibly foster cooperative research. The Dissemination Events also have the function of facilitating contacts between young researchers in the NoE and representatives of European companies for possible recruiting opportunities. Prior to the organization of the Dissemination events, a survey was carried out to focus and steer in advance the dissemination program.

A summary of WP3.4 progress towards objectives

Task 3.4.1 Survey of the Research Needs of European Companies

Task Leader: Hikmet Sari (Supelec)

This survey was made in the first year of the project and the results were included in Y1 Annual Report.

Task 3.4.2 Periodic Dissemination Events

Task Leader: Hikmet Sari (Supelec)

During the third year of NEWCOM#, the following dissemination events were held:

- Nokia Networks, Munich, Germany, 29 October 2014
- Telecom Italia, Turin, Italy, 26 February 2015
- Ericsson, Stockholm, Sweden, 4 May 2015
- Telefonica, Madrid, Spain, 16 June 2015
- Final NEWCOM# Event, Barcelona, Spain, 14 - 15 October 2015

The first of those events were actually held at the end of the second year, but it was not covered in the second-year report of the project. With these 5 events, NEWCOM# reached its goal of holding a total of 10 events during its 3 years. Also, in terms of attendance and interaction with associate partners from industry, these events were very successful. The biggest events were those held at Nokia networks and Telecom Italia. The first one gathered 35 people (26 from Nokia), and the second gathered 23 people (14 from Telecom Italia).

Following the dissemination events held during the 3 years of existence of NEWCOM#, there are now follow up actions with two partners: NEC Labs Europe in Heidelberg and Telecom Italia Future Center in Turin. Both companies are interacting with CNIT Bologna and cooperating. Finally, the Final NEWCOM# Event held in Barcelona on 14 – 15 October 2015 included an SME Event entitled “When Research Meets Business: Planning the Transition”. This event was very successful, with an attendance of over 60 people, and several panelists from SMEs.

WP 3.5 Development and valorization of human capital
WP Leader: M Danilo Abrignani (CNIT-UniBO)

This WP implements a number of actions to facilitate the development of personal skills and the growth of professional competence in research.
The instruments to achieve this are special grants mainly for PhD student and early-stage researcher to spend research period at external institution (priority given to the research stays at NEWCOM# EuWin Lab premises), a number of awards for papers and in general achievements obtained within the NoE, and a set of gender actions to promote the participation of female researchers. Communications of the outcomes of such actions are given with emphasis at the main NEWCOM#-related events and on the NEWCOM# newsletter and website to highlight at best their relevance in the context of a NoE.

A summary of WP3.5 progress towards objectives

Task 3.5.1 NEWCOM# mobility and “lab” grants
Task Leader: Luis M. Carreia

A call for mobility grant was launched this year. It was open on February 28th, 2015 and the deadline was on March 30th, 2015. The notification on the results of the call was given on June, using The Newcom# webpage, mailing list.

There were 7 researchers funded in this call for mobility grants, namely,

- Slawomir J. Ambroziak (Gdansk Univ. of Tech, Poland)
- Carmine Vitiello (CNIT-UniPI)
- Laura Galluccio (CNIT-UniCT)
- Burak Cakmak (Aalborg University)
- Li Wenjie (University of Paris Sud-CNRS)

- Gerherd Steinboeck (Aalborg University)
- Quentin Bodinier (CNRS-Supelec)

Four of them are PhD students, one is an experienced researcher and another one is a young researchers. Three of the recipients have spent one month in their hosting institution, while the others four spent between 5 to 10 weeks. Their research plans are well defined and provide great potential for writing highly visible scientific papers.

Task 3.5.2 NEWCOM# awards
Task Leader: Marco Luise (CNIT)

Similarly to the second year, three kinds of awards will be granted each year in order to promote excellence in research within NEWCOM#:

- The NEWCOM# Best Paper Award (BPA)
- The NEWCOM# Best Student Paper Award (BSPA)
- The NEWCOM# Distinguished Researcher Award (DRA).

In the second year the call was open on June 12, 2015. Submission deadline was on July 4 and final decisions by the Committee was be made on July 2015.
The Awards Grants were given during the Joint Newcom#/Cost Workshop on Wireless Communication – JNCW 2015. The awardees are:

- BSPA: Salvatore D'Oro for the paper: “Defeating Jamming With the Power of Silence: A Game-Theoretic Analysis”
- BPA: Abdellatif Zaidi for the paper: “On Cooperative Multiple Access Channels With Delayed CSI at Transmitters”
- DRA: i) Raymond H. Knopp (EURECOM, FR) and; ii)Adrian Kliks and Paweł Kryszkiewicz (Poznan T.U., PL).

Highlight of significant results from WP3.5

All seven persons that received mobility grants had returned from their stays. Reports were collected and high visible publications are to arise in few months.

For the awards, we received six applications for the BSPA and six applications for the BPA. Regarding the DRA, three applications had been collected; since during year 2 of the project no DRA was assigned, for the third year two DRAs had been assigned.
Overall, the aims pursuing by this WP have been fulfilled by the actions taken.

WP 3.6 The NEWCOM# Portal and related Web Presence Tools

WP Leader: Roberto Verdone (CNIT)

A fundamental and central instrument for dissemination, integration, and spreading of excellence is the NEWCOM# Portal that fosters communication among partners and with the NEWCOM# office, promotes a cooperative work environment, and showcase the life and achievements of the NoE. It will integrate as a heritage the Virtual Center of Excellence ViCE-WiCom tool which was developed in the framework of the NEWCOM++ project as an instrument to support knowledge sharing, and analysis of the relationships between content, people and activities into a knowledge map for the network. Besides, it also features dedicated sections on EuWIn where lab-specific information such as measurement campaigns, events, manuals or materials are posted, and hosts periodic issues of the “NEWCOM# NewsLetter” reporting on the life and achievements of the NoE. A videoconferencing tool named SCOPIA, allowing for a cost-effective realization of the

meetings of the various NEWCOM# bodies, or daily interaction of groups of researchers was made available through the portal, as well. The portal manages the relevant security issues when it comes to the protection of information, considering that the users of such tools are of many kinds, namely: the governing bodies of the NoE (some with unlimited access), the EC representatives (with dedicated areas), the NEWCOM# partners, the affiliate partners (with some restrictions), and the remaining interested parties from outside the NoE.

A summary of WP3.6 progress towards objectives

Task 3.6.1 Development of the NEWCOM# Portal
Task Leader: Rosa Martinez (CTTC)

This Task is over after Y1.

Task 3.6.2 The NEWCOM# NewsLetter and Social Networking
Task Leader: Adrian Kliks (PUT)

The LinkedIn NEWCOM# group was set up at the beginning of the project and, after two years, consists of 68 members. Besides, a NewsLetter, featuring the life and achievements of the NoE, has been published on a quarterly basis on the portal. To edit it, a collection of news and preparation of reports on the activity of each WP has been carried out. Some interviews to relevant NEWCOM# members were realized and included. The NewsLetter has been disseminated through the website and to the mailing list of NEWCOM#.

Task 3.6.3. Maintenance and Support
Task Leader: Lucia Vitiello (CNIT/UniBO)

During the third year CNIT worked on the update of the portal (e.g. information on events, workshops, schools, mobility grants, prizes, uploading of documents and calendar). As for the previous two years, help was offered to users and contributors in what concerns both content management and technical support about the usage of the NEWCOM# portal and of its features.
During the third year the EuWIn website was mantained.

All web related tools needed to support the networking and integration activities have largely facilitated a fruitful cooperation among scientists and the dissemination of project results.

A server hosting the NEWCOM# web tool is directly managed at CTTC. The features currently implemented are:

- a special restricted section for Advisory Board
- a special restricted section for the MPA
- a news and events public area
- a public area to showcase the NoE, its activities and public results (most of the deliverables) to the external scientific community
- a 'Mobility Grant' section
- a restricted areas to exchange documents, data and materials within the NoE
- a N# papers section
- a Schools section
- a Workshop section
- a JNCW'15 Final Event section
- an "Awards" section
- a Calendar section
- a Deliverables section

A server hosting the videoconference solution SCOPIA is directly managed by CTTC, as well as a hosted solution for more than 40 mailing lists.

A server hosting the EuWIn web tool is directly managed at CNIT.

2.2.4 TRACK 4 (WP 4.1)

Track Leader: Carles Anton-Haro (CTTC)

In this Deliverable only WP 4.1 is reported, since the other WPs of this Track (WP 4.2 and WP 4.3) are reported in Deliverable D43.2.

Broadly speaking, the management activities in a NoE, in addition to setting up and maintaining the legal basis for operation of the NoE, are instrumental to make sure that all partners follow the correct procedures in the administration of their own budget, and that prepare timely and accurate reports to the Coordinator and/or to the Commission where requested. In addition, the network management has also to implement due auditing actions to possibly identify spending unbalance issues among partners as well as possible non conformity of some partner's activity to the work program of the NoE. In the case some non conformity (financial or scientific) is detected, proper corrective measures are proposed to the Executive Board of the NoE.
Complementarily, it also includes the yearly update and further refinement of the Joint Program of activities taking into account inputs from the Advisory Board and EC project review meetings.
Along with that, some dynamic allocation of NoE budget according to individual partners' performance is also envisaged in NEWCOM#, in such a way that the potential of those having shown larger impact towards the project objectives can be increased.
Finally, another fundamental output of the management activities is a constantly updated review of the status of the NoE that will also allow to evaluate its sustainability after the Commission funding is over. This is done by implementing specific actions about promotion of the NoE activity and by identifying the most promising aspects in the network (e.g., the EuWIn lab) that can be possibly turned into some form of self-sustaining business. The Management activities within NEWCOM# are organized into three WPs, each regarding one of the main aspects mentioned above.

WP 4.1 Direction and quality assurance of scientific activities

WP Leader: Marco Luise (CNIT)

This WP summarizes the most crucial steering and coordination functions of the Project Coordinator for the everyday proper working of the NoE; it is related to the proper implementation and management of the research WPs (Tracks 1 and 2) and training and dissemination WPs (Track 3). There are numerous tasks carried out within this WP, most importantly:

- assessing/enhancing with the help of the Advisory Board the quality of the results produced by the NoE in terms of scientific and technical innovation;
- assessing/monitoring the quality and timely delivery of documentation (deliverables).

Potential deviations and/or critical issues (in terms of scientific content and/or documentation quality) are identified in due time and reported to the Executive Board, that takes appropriate actions towards the WPs to solve the issue. Network promotion and sustainability aspects are also addressed in this Work Package, together with the fundamental issue of the access policy to EuWIn.

A summary of progress towards objectives

This WP deals specifically with all aspects related to the proper implementation and management of the research WPs. This includes the assessment and possibly the enhancement of the quality of the results obtained from the NoE in terms of scientific and technical innovation. The WP activities are split into 3 tasks: Task 4.1.1 "Scientific quality control", Task 4.1.2 "Management of the Executive Board and the Advisory Board", Task 4.1.3 "Network promotion and sustainability".

Task 4.1.1 Scientific quality control
Task Leader: Marco Luise (CNIT)

One of the main, and more time-consuming activities of this WP has been the scientific quality control of the research deliverables and the coordination of Track1-Track2 activities and cooperation. Sixteen deliverables have been produced in Year 3 and each deliverable first underwent an internal (to the specific research WP) review, then has been reviewed by the Track Leader and finally it has been duly reviewed by NEWCOM# Scientific Director (Track 1, 2 and 3) and by the A&M Director (Track 4). In this way the Scientific Director has had an overall visibility of the network scientific production, and could provide actions to coordinate the deliverables content to avoid duplications and increase synergies.
The WP activity has been mainly accomplished by the NEWCOM# Scientific Director, in close cooperation with the Managing Director and NEWCOM# Office. The EB members have been actively involved in network management and committed to its proper functioning.

Task 4.1.2 Management of the Executive Board and the Advisory Board
Task Leader: Marco Luise (CNIT)

As to the management of the Executive Board (EB), 4 meetings have been held:

EXECUTIVE BOARD MEETINGS	
VENUE	**DATA**
Athens, Greece	January 20, 2015
virtual	March 12, 2015
Donnini, Italy	June 22-23, 2015
Barcelona, Spain	October 14, 2015

The General Assembly was held by teleconference on 7th July 2015, and has approved (amidst other items) the change in the revised budget and the second interim payment. The last General Assembly was held on 18th November 2015 and has approved the third revised budget.

The meeting of the Advisory Board took place at the Final Event @ Joint NEWCOM/COST Workshop on Wireless Communications JNCW 2015, on 4th October in Barcelona (Spain). The goal was to inform the AB of the progress of the activities of the network. On that occasion, they have been asked to express their opinin on the survavailability of the network.

Task 4.1.3 Network promotion and sustainability
Task Leader: Simona Moschini (CNIT)

This Task is discussed in detail in section 4 of this Deliverable.

3. Project publications during the reporting period

As Figure 3.1 (left, top) illustrates, a total of 173 journal and conference papers (54 and 119, respectively) have been published or accepted for publication in the third year of the project (see full list of publications in Annex V). The total number of publications for the whole project duration is 488 which is very high. The scientific production in the third year accounts for a 35% of the total production, and it virtually doubles that of the first year. More importantly, 79 of Y3 publications, or roughly 50%, turn out to be joint publications. This percentage evidences that the project has made a very substantial progress in terms of research integration (to recall, the percentage of joint papers in the first year was roughly 33%). Not only that, bearing in mind the extra time and efforts required to produce a *joint* paper, the fact that in total 212 papers came into light in three years is, by itself, a major success: partners spent more *time* in joint papers than in individual ones. Further details on the number of contributing institutions to those publications can be found in Figure 3.1 right (for year 3). As in previous reporting periods, joint publications where two partners collaborate are the most frequent ones (57% of joint publications). However, the number of joint publications involving 3 partners has substantially increased (2013: 2; 2015: 19); and, simultaneously, the number of joint publications by two partners from the same country has decreased (2014: 23; 2015: 5). This again, illustrates the structuring effect of NEWCOM#, which has resulted into larger-scale and more international collaboration networks.

Publications Y3	Conference	Journal	Total	%
Joint	54	25	79	46%
Individual	65	29	94	54%
Total	**119**	**54**	**173**	

Publications Y1..Y3	Conference	Journal	Total	%
Joint	144	68	212	43%
Individual	185	91	276	57%
Total	**329**	**159**	**488**	100%

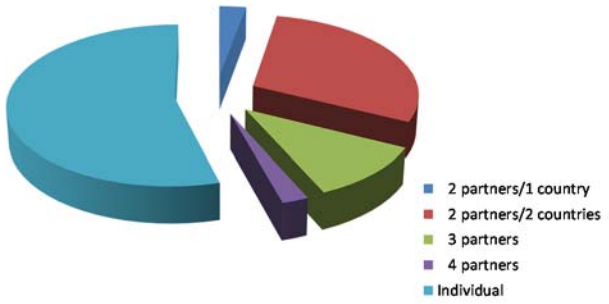


Figure 3.1: *Publications either published or accepted for publication. Details on conference/journal and joint/individual distribution during the third year and the whole project duration (left); and on the number of contributing institutions for year 3 (right).*

Figure 3.2 and Table 1 show the breakdown of publications into workpackages. The following trend, already observed in Y2, consolidates: on average, the number of publications generated by Track 1 ('Theoretical') workpackages is substantially higher than that of Track 2 (EuWIN, 'Experimental'). This stems from the fact that, in general, the time needed to publish results based on experimental work is much higher. Despite of this, the number of publications of WP2.1 is well above the average number of publications in Track 2 workpackages. Besides, it is very close to that of WP1.3 (a *theoretical* workpackage). Within Track 1, the most productive workpackage turns out to be WP1.1. However, WP1.2 is more balanced in terms of joint and individual publications. And, interestingly enough, the number of joint publications of WP1.3 in Y3 exceeds that of individual ones.

Finally, Table 1 provides further details on the breakdown of joint publications per workpackage as a function of the number of co-authors. This is done both for Y3 and the whole duration of the project.

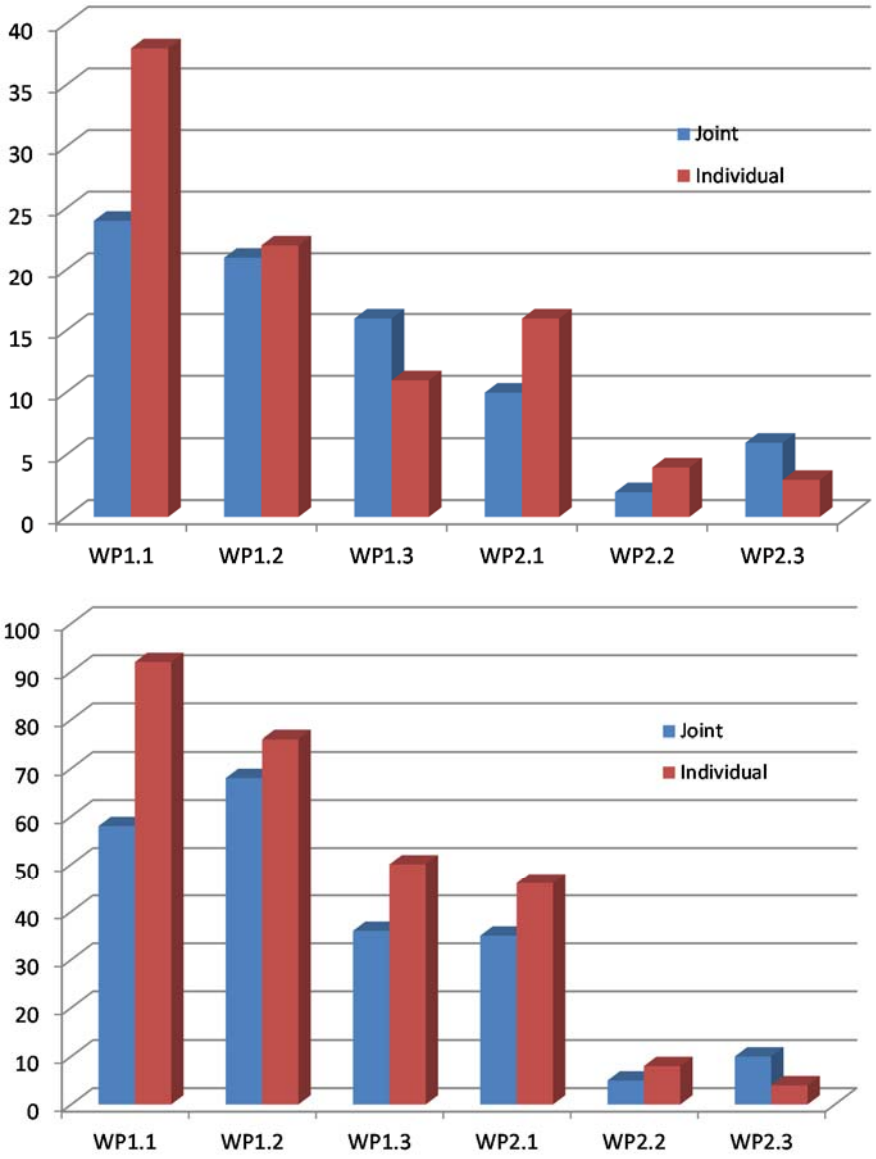


Figure 3.2: *Number of joint and individual publications per workpackage*. Top: third year. Bottom: whole project duration.

Table 1: *Breakdown of publication type per workpackage*. Top: third year. Bottom: whole project duration.

Publications Y3	WP1.1	WP1.2	WP1.3	WP2.1	WP2.2	WP2.3	Total
Joint	**24**	**21**	**16**	**10**	**2**	**6**	**79**
2 partners/1 country	0	1		3	1		5
2 partners/2 countries	13	17	11	6	1	3	51
3 partners	10	3	2	1		3	19
4 partners	1		3				4
Individual	**38**	**22**	**11**	**16**	**4**	**3**	**94**

Publications Y1..Y3	WP1.1	WP1.2	WP1.3	WP2.1	WP2.2	WP2.3	Total
Joint	**58**	**68**	**36**	**35**	**5**	**10**	**212**
2 partners/1 country	1	18	3	14	4	0	40
2 partners/2 countries	40	40	27	15	1	7	130
3 partners	16	9	3	6	0	3	37
4 partners	1	1	3	0	0	0	5
Individual	92	76	50	46	8	4	**276**

4. Network promotion and sustainability

4.1 The questionnaire: NEWCOM# Consortium Feedback

The first step in the promotional strategy during the first year of the project (Y1) has been the creation of communication material (leaflets, bookmarks, gadgets) to advertise the network. The promotional materials were circulated in the NEWCOM# schools, workshops and dissemination events held in the first year.

The second step, taken in Y2, consisted in setting up and putting into action an effective promotion campaign that highlighted the benefits of keeping the network alive after the EC funding period. To that aim, an on-line questionnaire was prepared, the circulation of which was restricted to NEWCOM# partners and Affiliate Partners. It was aimed at identifying the benefits of the network on personal and organizational level, as well as possible critical deficiencies to be fixed. See the questionnaire in D41.3@Annex I or online at
http://www.newcom-project.eu/index.php?option=com_content&view=article&id=126&Itemid=204

4.2 Outcome of the NEWCOM# Consortium Feedback

The outcome of the questionnaire is reported in Annex I and it has been used in Y3 to setup a path to be used for a “survival plan”.

The questions were intended to assess the satisfaction of the researchers about the activities carried out within the NoE, and to rank their own relevance in preparation of the future of our community. To sum up in a few lines the raw data, we may say that:

i) The integration across partners is achieved, it is considered a success, and a must for the future.
ii) The integration between experimental and theoretical research has not been fully achieved. Perhaps a period of 3 years was not enough to attain this objective. Also researchers into our NoE comes mainly form a community focused on theoretical research, and it shows.
iii) What researchers most consider a success and a need for the future is the organization of schools, workshops and meetings. This is in full agreement with the outcome of the “Survival” session organized at the project plenary meeting in Athens, as we report in 4.3 below.

The researchers’ viewpoint, as resulting for the questionnaire, is actually reflecting what we call the “NEWCOM spirit” and the real *raison d’etre* of an NoE: putting in place initiatives to let researchers cooperate. In this respect, the potential of EuWin as a shared laboratory for everyone has not been completely attained.

4.3 The Survivability Sessions @ Joint Track 1-2 in Athens

During the joint Track1/Track2 meeting held in Athens on January 20/22 2015, it was organized a specific panel with discussion on the survivability of NEWCOM# after the grant is over. The event has been a success with about 45 persons attending.

The main outcomes of the discussion are the following: i) everybody agreed on the opportunity to go on with the activities of the association EURACON; ii) the opportunities given by EuWin have to be exploited in the next calls of H2020: iii) we have to find a way to go on with the organization of periodical technical meetings and workshops to discuss and

coordinate research. The last point was considered the most important, and so there was consensus about the participation to the joint preparation, together with the researchers form COST Action IC 1004, of a new COST action about 5G.

4.4 The NEWCOM# Young Researchers Questionnaire

NEWECOM# cares a lot about the young researchers' work and view of the future. This is the reason why the Young Member of the Executive Board for Y3 has been appointed to edit and circulate a special questionnaire (in Annex II) only for young researchers (up to 4 years after PhD Defence) in order to bring their views into the Survivability Panel in Athens.

This has been a unique opportunity for them to shape part of our future in research.

The Young Member of the EB reported the results in the Survivability Panel; here in Annex III the details about the statistics.

The questionnaire was structured as follows:

- Profiling the researcher: few questions where we tried profiling the young researcher in terms of experience, field of expert, research activities (Theoretical oriented, Experiment oriented or both)
- Research vision: in this part, we asked researcher them "position" with respect to experimental research and the future of the research (more market/experimental oriented or theoretical oriented/curiosity driven).
- Inclination to collaboration: mainly information above the collaboration, i.e. number of JRAs, number of partners per JRA, if and how carry on the JRA after NoE end
- How to go further: some open suggestion on what researcher will miss and what they had missing more in NEWCOM#, suggestion and hypothesis on how to go further.

Profiling the researcher:

The average research age of N# Young Researchers is 6.5 years. 31 questionnaires submitted, where 19 are from PhD Student.

Research vision:

In this section, we asked researchers, them position with respect to experimental and theoretical activities. The former is more market-oriented research; while the latter is more curiosity driven.

The results are very interesting; 75% of the researchers are interested in experimental activities.

Accordingly, we asked directly what researchers think on "timing" in research project: most of them think that it is needed to find a compromise between market- and curiosity- driven research.
The attractiveness is testified by the fact that 40% of the researchers said that they are not working on experimental activities but they will start.

In the last question of this group we made a sort of ranking where different features were listened. People asked for remote access, and it is reasonable, it makes research faster because you do not need to move in other place, sometime others institutions. However, Travel Grants are perceived as very important tool to pursuit experimental research, meaning people feel that is important to move where the experimental platform is.

Inclination to collaboration & how to go further:

More than 90% of young researchers are actively involved on JRAs. More in details, half of them are involved in more than 2 JRAs and, in different ways, roughly 80% of the JRAs will be carrying on after Newcom# is over. This is a great result: activities born within "Newcom saga" will survive, meaning that the NoE reached its goal to establish strong link between institutions.
Accordingly, answers to the last question ranking well-known collaboration tools like FET and MCSA in the first and second position respectively.

4.5 Other dissemination/promotion activities

NEWCOM# has been represented in several meetings, where the project activities have been presented:

- Participation in the EuCNC – European Conference on Networks and Communication held in Paris on June 29- July 2, 2015.
- Participation and presentation in the Concertation Meeting held in Brussels on Wednesday, 25 March on the fringes of the "NetFutures 2015" event (http://netfutures2015.eu).
- Organization and presentation in the Tyrrenian Workshop (12-14 Sept. 2016, Livorno, Italy) (http://www.tyrrhenian.cnit.it/).

Other dissemination and promotion activities have been:

- ICT-NEWCOM# and COST-IC1004 signed a liaison agreement in mid 2014, creating a channel for many forms of interaction. This agreement was built on the common interests of these two projects, and particularly the aspects related to cooperative communications, MIMO systems, radio channel modeling.
  COST-IC1004, coordinated by Prof Narcis Cardona of the Polythecnic University of Valencia, supported European industries in the pre-deployment phase of the transition from 4G to 5G networks. It was participated by more than 100 institutions; more than one third were industries that benefit from the outcome of the project.
- After the Newcom# dissemination event at Telecom Italia Labs premises in 2015, EuWIn@UniBO organised a full day meeting in Bologna with the head of the Telecom Italia Future Center. After the meeting, two actions were taken:
  - establishment of a PhD position at UniBO fully funded for three years by Telecom Italia;
  - start of a discussion finalised to the possible duplication of the EuWIn FLEXTOP testbed at the premises of Telecom Italia Future Centre in Venice; this action is still ongoing.
- Newcom# and the former COST Action IC1004 submitted a new proposal of COST Action, IRACON, representing the merge between the two communities. In particular, the WorkProgramme of IRACOn, based on seven WGs, includes three WGs which represent the follow-up of EuWIn initiatives and spirit.
  The proposal has been formally approved on October 30, 2015. The new COST Action, that will allow survival of EuWIn spirit for the next four years, will probably start in january 2016.

5. Conclusions and Prospects

Some concluding remarks after the body of the work presented in the previous sections are in order.

In terms of scientific joint activity, the NoE has fulfilled its expectations, confirming on Y1 and Y2 in terms of quality and quantity of the results that are being produced. We have attained a considerable level of integration into Track 2, albeit within a subset of partners (those interested into experimental work). Track 1 still proves to be more universal than Track 2 in terms of interest received form partners – this is clearly an heritage coming for the history of the NoE.

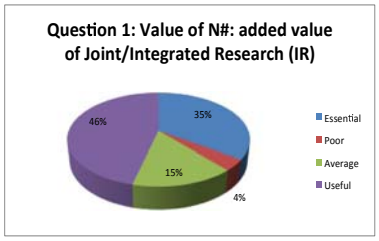
Concerning dissemination and training (Track 3), our results are very good in general as well. Dissemination events at companies are well received, and a final event geared towards ME has been organized with a great success. Schools, workshops, special sessions, special issues in journals are good in quality and quantity – especially schools attract a large number of early stage researchers also from outside the NoE. The final event of the NoE has been organized in Barcelona with an attendance of almost 100 people, and some events are being organized after the end of the project, that still acknowledge the contribution from NEWCOM# (www.tyrrhenian.cnit.it).

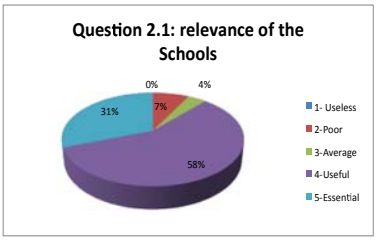
As a first “survival” action, and as a results of the cooperation MoU signed with COST action IC 1004, the NoE has contributed to the preparation of a new COST action proposal, jointly with the community of the expired IC 1004 action. It is news of these days that the resulting action CA15104 IRACON has been accepted.

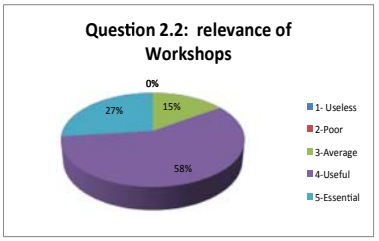
All NEWCOM# partners, while acknowledging the consideration of their work by the European Commission and the invaluable support received by the Project Officer Remy Bayou, hope that more opportunities will be given to Academic research within H2020, beyond the pre-structured project by 5GPPP, so that the capital of knowledge and relations built during the present project shall not be wasted in the future. A few ideas in this respect are summarized in Annex IV.

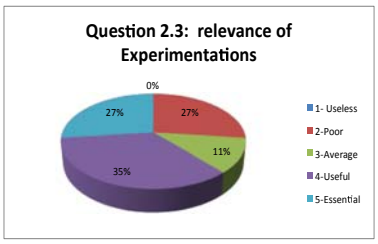
6. Annexes

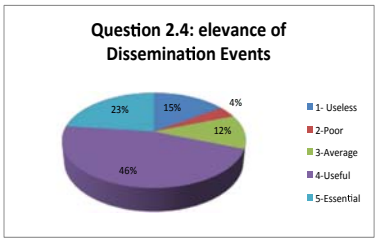
6.1 Annex I: The NEWCOM# Consortium Feedback OUTCOME

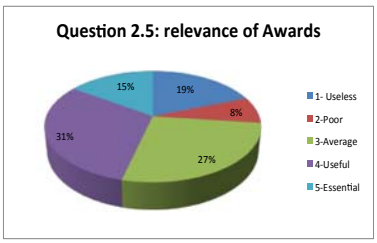


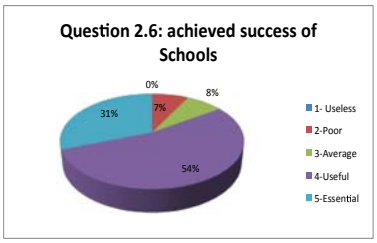


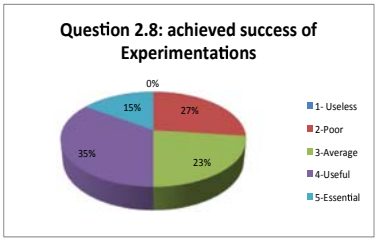


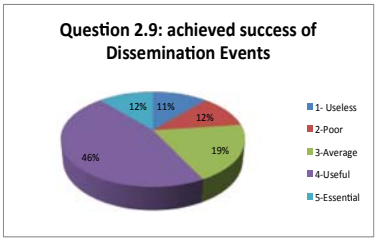


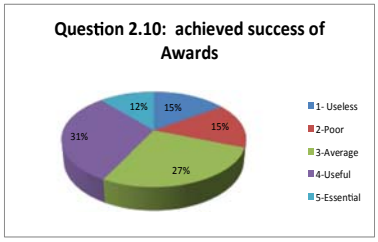


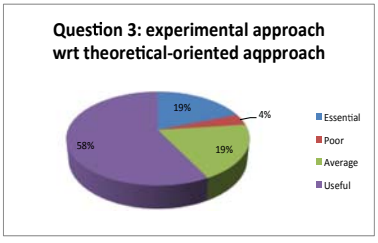


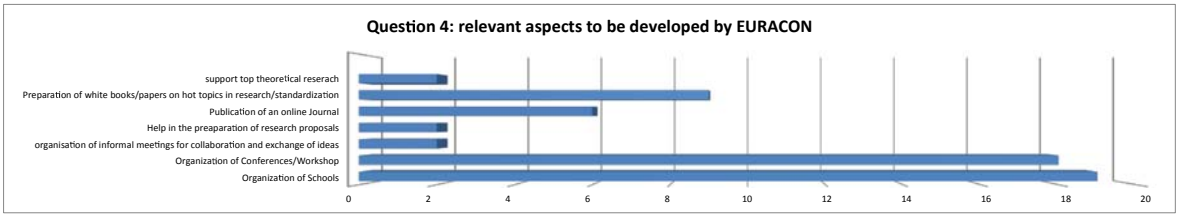


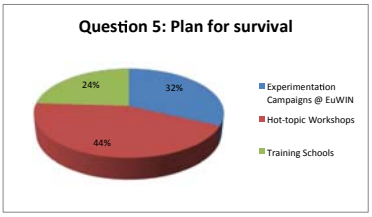


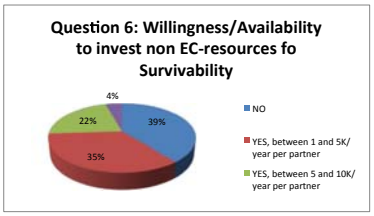


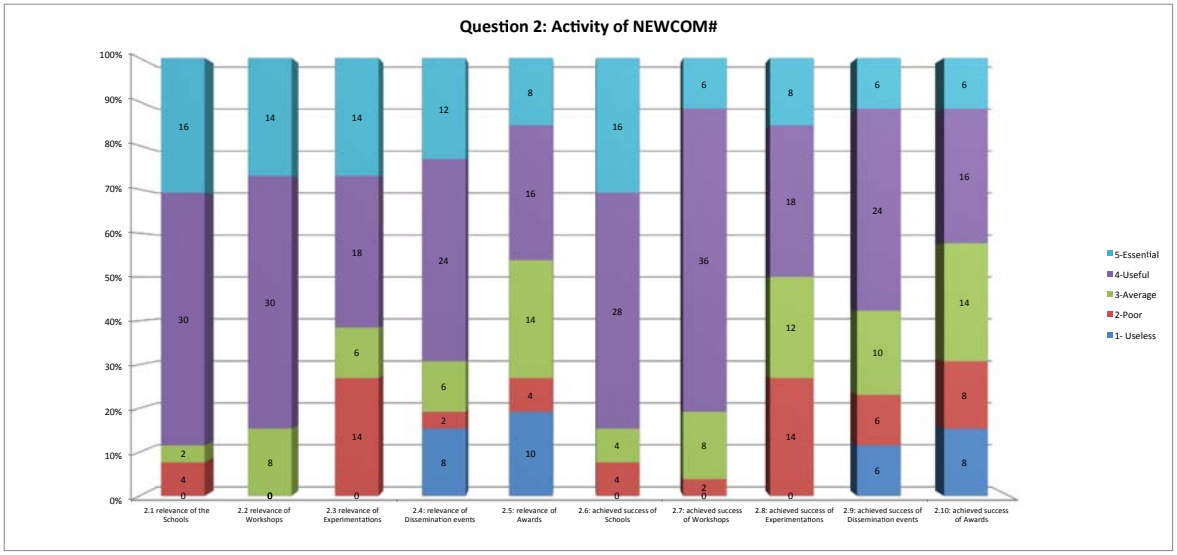





Question 4: relevant aspects to be developed by EURACON
support top theoretical reserach
Preparation of white books/papers on hot topics in research/standardization
Publication of an online Journal
Help in the preaparation of research proposals
organisation of informal meetings for collaboration and exchange of ideas
Organization of Conferences/Workshop
Organization of Schools
0
2
4
6
8
10
12
14
16
18
20


Question 5: Plan for survival
24%
32%
44%
Experimentation Campaigns @ EuWIN
Hot-topic Workshops
Training Schools


Question 6: Willingness/Availability to invest non EC-resources fo Survivability
4%
22%
39%
35%
NO
YES, between 1 and 5K/ year per partner
YES, between 5 and 10K/ year per partner


Question 2: Activity of NEWCOM#
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2.1 relevance of the Schools
2.2 relevance of Workshops
2.3 relevance of Experimentations
2.4: relevance of Dissemination events
2.5: relevance of Awards
2.6: achieved success of Schools
2.7: achieved success of Workshops
2.8: achieved success of Experimentations
2.9: achieved success of Dissemination events
2.10: achieved success of Awards
5-Essential
4-Useful
3-Average
2-Poor
1- Useless

6.2 Annex II: The NEWCOM# Young Researchers Questionnaire

Young Researchers Questionnaire

i.e. till four years after PhD defence

*Campo obbligatorio

Your Research Age *

defined as the current number of years after the M.Sc. degree

Are you currently a PhD Student? *

the current number of years after the M.Sc. degree

Field of Expertise: *

- ☐ Channel
- ☐ PHY
- ☐ MAC
- ☐ Network / Upper Layer

Are you more interested in *

- ☐ Theoretical Research (Mathematical Modelling / Simulations)
- ☐ Experimental Research (Lab Facilities /Test beds)

The Country where you are currently working/studying:

Continua »

25% completato

Young Researchers Questionnaire

i.e. till four years after PhD defence

*Campo obbligatorio

H2020, with respect to FP7, is pushing forward Innovation as a key element that should be reflected in all projects; in other words, project results are more oriented to the short term than in the past; with respect to this, which of the following sentences is more representing you: *

- ○ I like the idea that research should be closer to the market
- ○ Research should find a compromise between market needs and long term visions
- ○ I believe research should be only curiosity driven
- ○ Altro:

In Scientific Literature the use of the keyword "Experimental" is increasing at least by 30-40% on a yearly base; with respect to the last statement, which of the follow sentences is more representing you: *

- ○ I'm planning to work on / I want to be an experimental research expert
- ○ I just started (since 1-2 Years)
- ○ I am working on (since 3-4 Years)
- ○ I'm an expert of / I am leading experimental activities
- ○ I'm not interested at all
- ○ Altro:

Which of the following features would increase your interest on experimental activities (you can choose more than one): *

- ☐ Remote Access to the experimental facilities
- ☐ Connection with Matlab/Octave
- ☐ Meta-Language Programming feature (Block Programming like Simulink)
- ☐ Travel Grants (on-site activities)
- ☐ Altro:

« Indietro Continua »

50% completato

Young Researchers Questionnaire

i.e. till four years after PhD defence

*Campo obbligatorio

Within the work programme of Newcom#, how many JRAs are you involved in?

- ○ 1-2
- ○ 3-4
- ○ >4

How many partners are involved in your JRA?

- ○ 1-2
- ○ 3-4
- ○ >4

Are you planning to carry on the collaborations set through your JRA after Newcom# is over? *

- ○ Yes, on academia /industry funds
- ○ Yes, we collaborate because of other EC projects
- ○ Yes, mainly with virtual meetings
- ○ No, we are concluding our collaboration
- ○ No, I have not been involved in any JRA

« Indietro Continua »

75% completato

Young Researchers Questionnaire

i.e. till four years after PhD defence

*Campo obbligatorio

What was missing in Newcom# with respect to your expectations as a researcher?

one to three items, few words/sentences each

What will you miss more from Newcom# after its end?

one to three items, few words/sentences each

H2020 promotes three main action programmes for fundamental research: Marie Skłodowska-Curie Action (MSCA), FETs and Research Infrastructures (RI); in your opinion, the Newcom# future will relief on: *

details on UE actions: http://ec.europa.eu/research/

- ☐ MCSA
- ☐ FET
- ☐ RI
- ☐ Nothing
- ☐ Altro:

Young Researchers Questionnaire

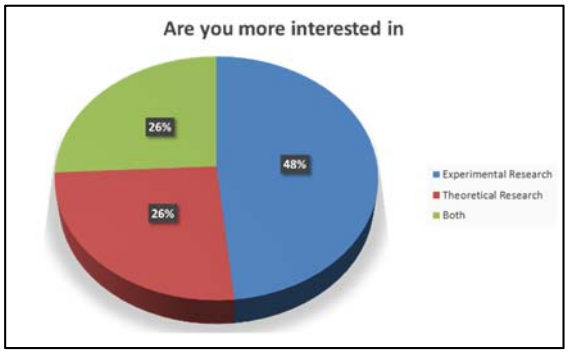
i.e. till four years after PhD defence

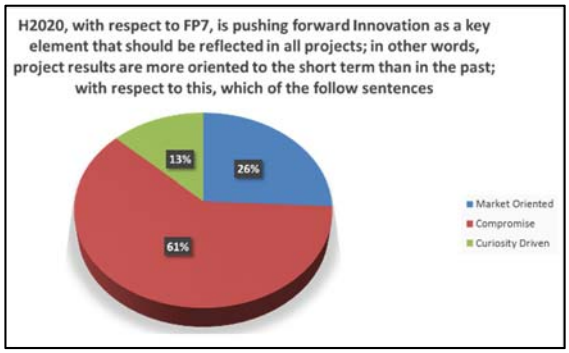
Any suggestion you would like to give / any statement you would like to have commented by the more experienced scientists in Newcom#, with respect to the theme "how to let Newcom# survive after its end":

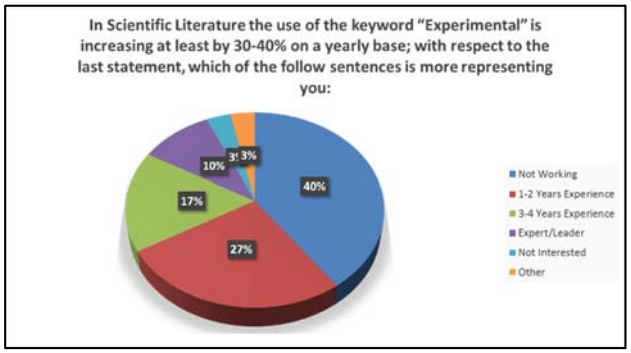
« Indietro Invia

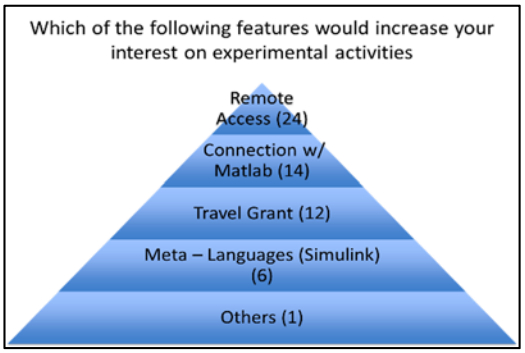
100%: completato.

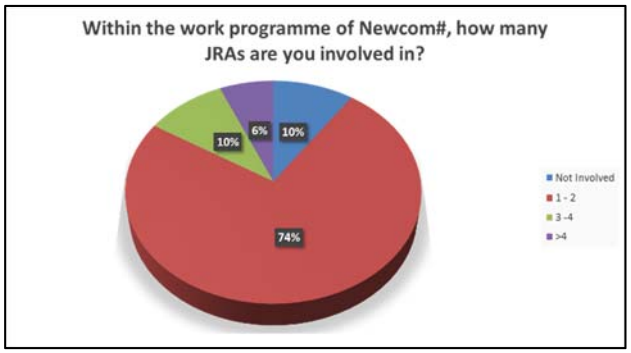
6.3 Annex III: The NEWCOM# Young Researchers OUTCOME

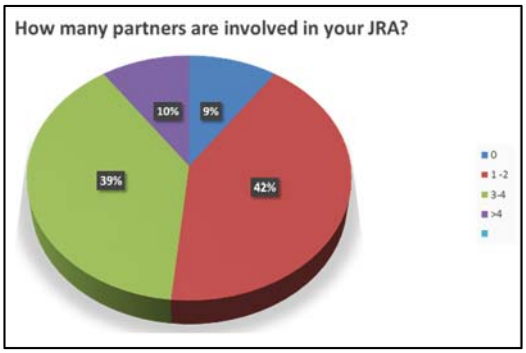


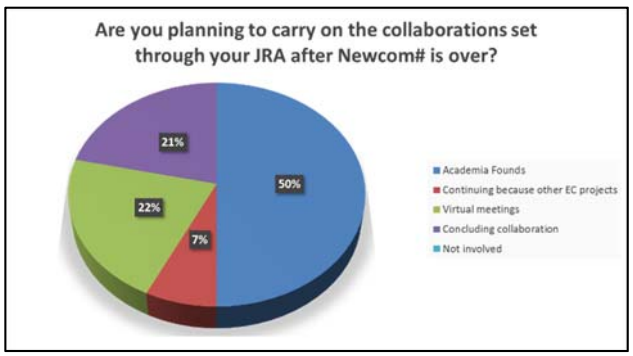


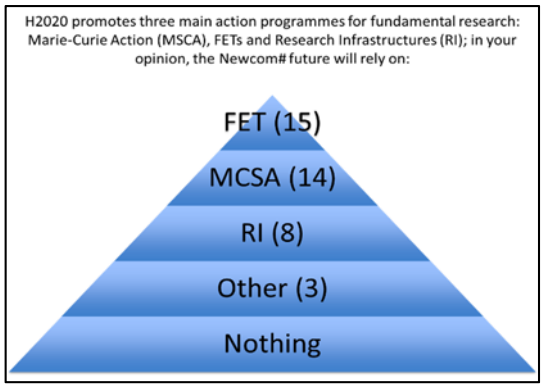






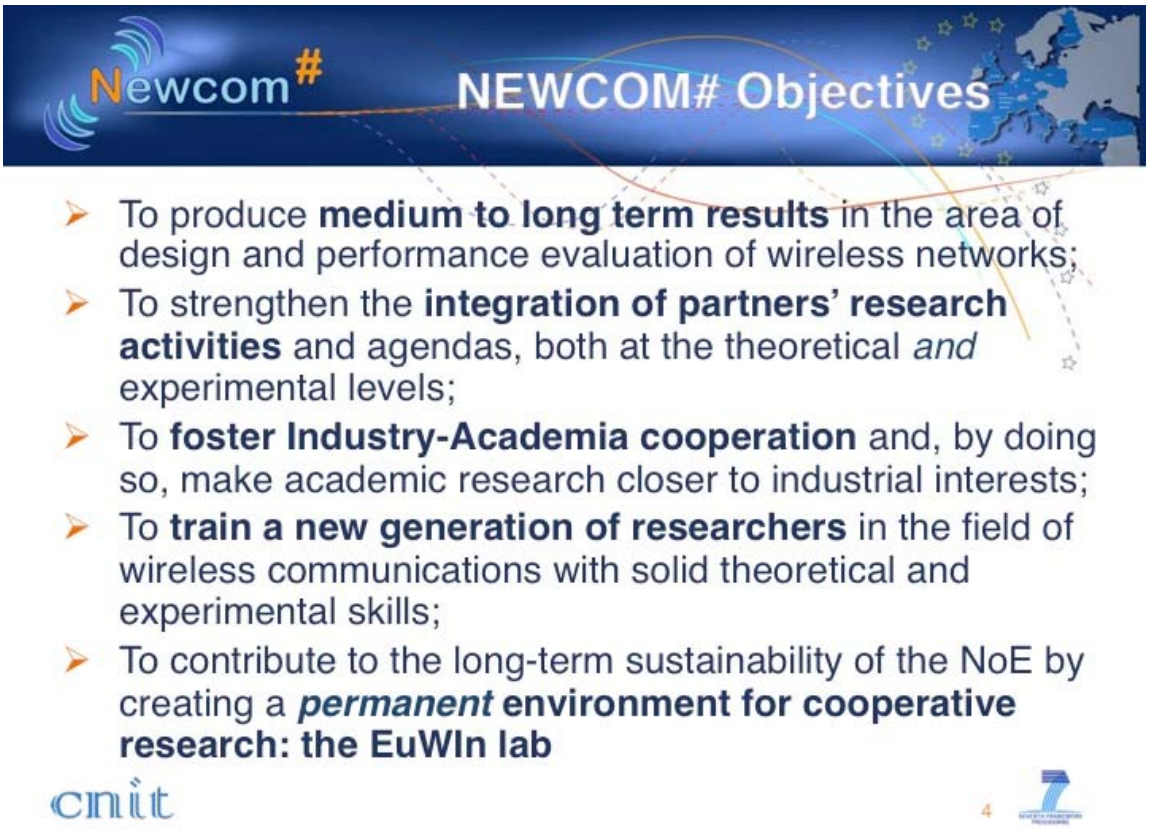






6.4 Annex IV: Coordinator's Presentation for JNCW 2015 Joint NEWCOM/COST Workshop on Wireless Communications


Newcom#
Excellence within Excellence
Newcom
Newcom++
Newcom#
NEWCOM : 2004-2007, 60 partners
NEWCOM++ : 2008-2010, 17 partners
NEWCOM# : 2012-2014, 14 partners
Overall financing by the European Commission close to 16 Million Euro
Overall effort of 3400 person-month
cnit
3


Newcom#
NEWCOM# Objectives
To produce medium to long term results in the area of design and performance evaluation of wireless networks;
To strengthen the integration of partners' research activities and agendas, both at the theoretical and experimental levels;
To foster Industry-Academia cooperation and, by doing so, make academic research closer to industrial interests;
To train a new generation of researchers in the field of wireless communications with solid theoretical and experimental skills;
To contribute to the long-term sustainability of the NoE by creating a permanent environment for cooperative research: the EuWIn lab
cnit
4

NEWCOM# Partners

1 **CNIT** – Italy (Coordinator)
3 **AALBORG UNIVERSITET** - Denmark
4 **BILKENT UNIVERSITESI** - Turkey
5 **CNRS** Paris - France
6 **CTTC** Castelldefels - Spain
7 **IASA** Athens - Greece
8 **INOV** Lisbon - Portugal
9 **POZNAN UNIVERSITY OF TECHNOLO** Y - Poland
10 **TECHNION** Tel Aviv - Israel
11 **TECHNISCHE UNIVERSITAET DRES** EN - Germany
12 **UNIVERSITY OF CAMBRIDGE** - UK
23 **UNIVERSITE CATHOLIQUE DE LOUVAIN** Belgium
24 **OULUN YLIOPISTO** - Finland
25 **TECHNISCHE UNIVERSITAET WIEN** Austria

cnit

5

FACTS and FIGURES

- Total NoE duration: 36 months
- 14 partners from 14 different countries
- 16 Work Packages organized in 4 Tracks
  - 3 WPs on theoretical research (234 pm's)
  - 3WPs on the EuWIn (187 pm's)
  - 6 WPs on dissemination and training (141 pm's)
  - 3 WPs on management and NoE sustainability (34 pm's)
- Overall effort: 596 person-months
- Total Cost: 5.551 M€
- EC contribution: 2.846 M€
- 16 Affiliate companies
- (More than) 300 researchers involved

cnit

6

Wireless Communications in the '90s: A challenge *per se*

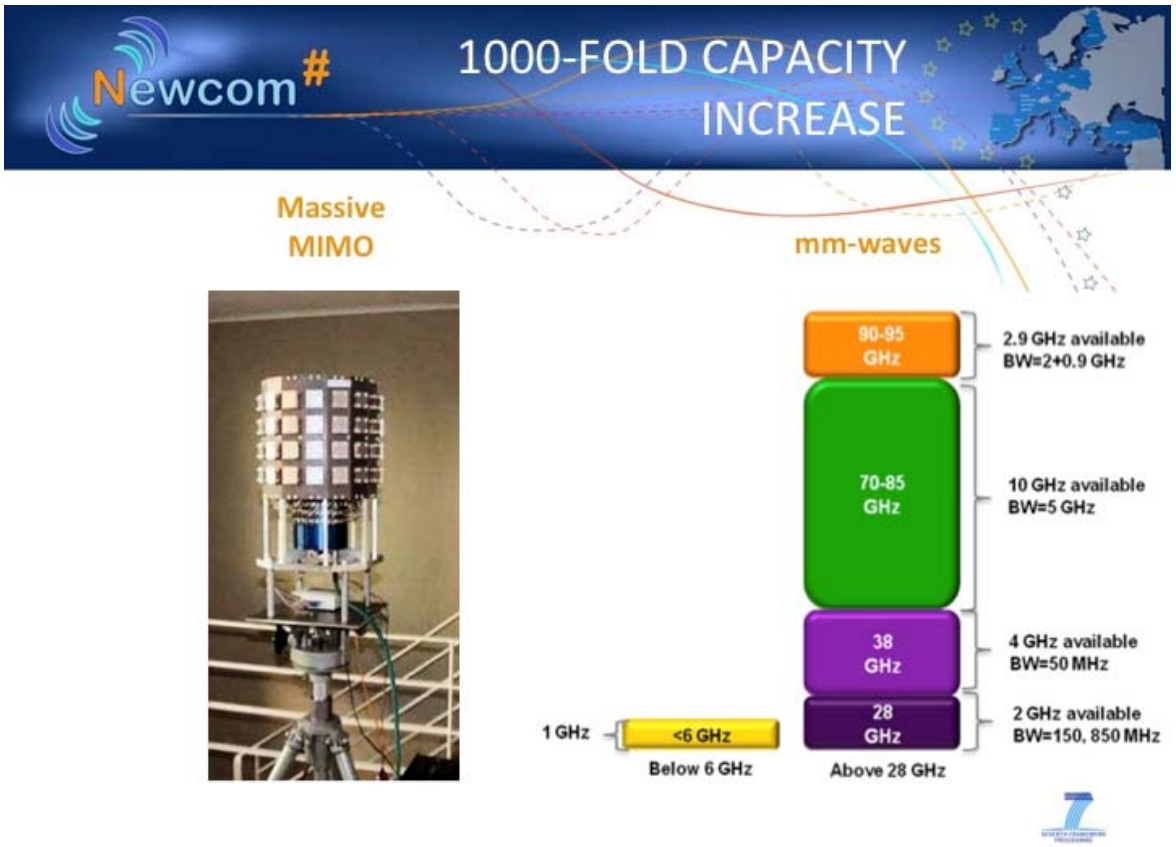
Wireless Communications in the 00's: A segment of the *Future Internet*

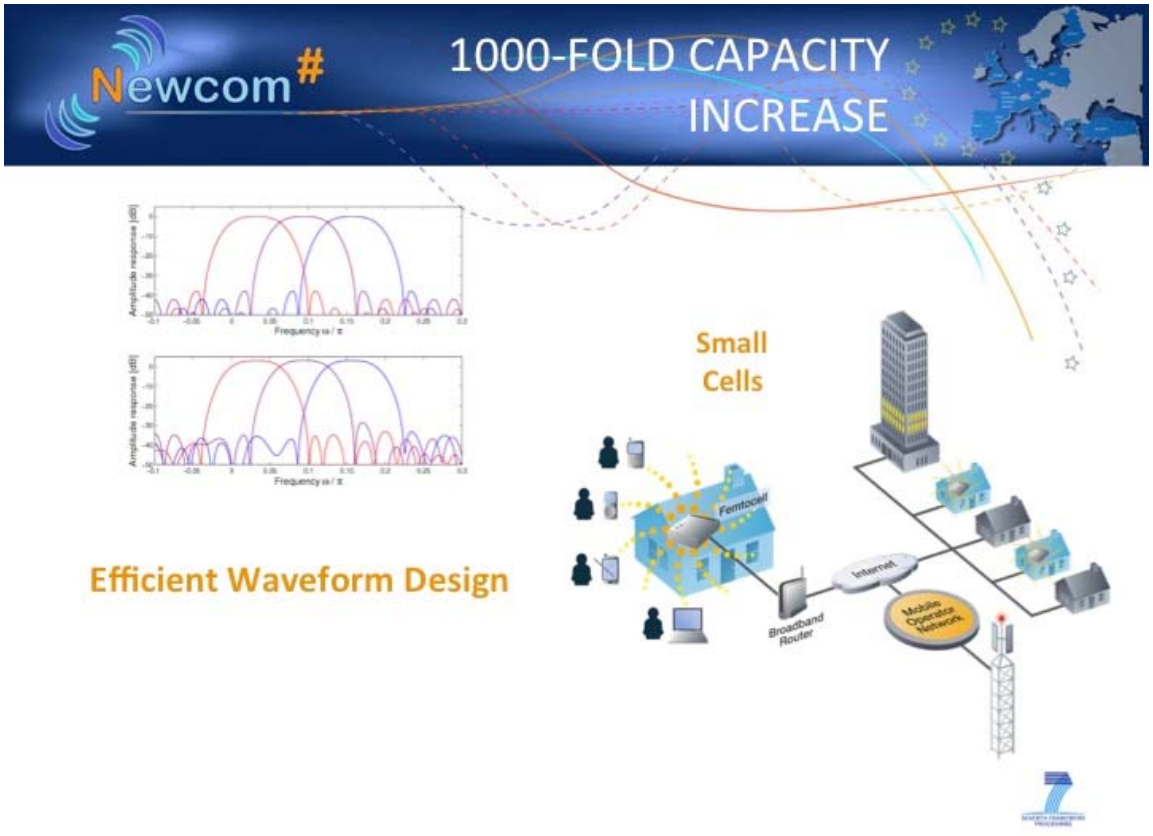
Wireless Communications in the 10's: *Wireless for…* (transportation, health, smart entities…)

Wireless Communications in the '20s ??

Is research in radio communications still relevant and exciting? Is it still a challenge for companies and research Institutions in the EU ? Will we really need it in the '20s ?

- To 5G or not to 5G?
  - 5G is almost here, with fundamental research we should already start thinking of B5G…
- Our view of European Leadership
  - Are there any capacities that are missing to keep it?
- Lessons learnt & Way forward
  - Metcalfe's law and cooperative/integrated research
  - Let's not waste our capitals


Newcom#
1000-FOLD CAPACITY INCREASE
Massive MIMO
mm-waves
90-95 GHz
2.9 GHz available BW=2+0.9 GHz
70-85 GHz
10 GHz available BW=5 GHz
38 GHz
4 GHz available BW=50 MHz
28 GHz
2 GHz available BW=150, 850 MHz
1 GHz
<6 GHz
Below 6 GHz
Above 28 GHz


Newcom#
1000-FOLD CAPACITY INCREASE
Efficient Waveform Design
Small Cells
Femtocell
Broadband Router
Internet
Mobile Operators Network

B5G FOR THE '20S 1/2

- **Cooperative networking**
  - Nothing to do with Massive or Distributed MIMO: massive relaying of messages in a dense (peer-to-peer) network
- **Noisy Networks**
  - Strategies for network coding and its interplay with routing
- **Cooperative Robust Interference Alignment**
  - Overcomes the notion of resource allocation/sharing and interference cancellation
- **Physical-layer security**
  - Encryption-less enhanced security of radio access with adaptive features of the radio interface

B5G FOR THE '20S 2/2

- **Distributed Caching/Storage and Social networking**
  - Information Flow and Information Storage goes hand-in-hand. It pairs the issue of cooperative communications and exploits the spatial correlation of information in population of users
- **D2D with non-cellular architecture**
  - Internet of Things 2.0 – it is again configured as a peer-to-peer low bit-rate, very high density network with possible cooperation
- **Integration with broadcast**
  - Unique radio interface with cellular and D2D ? Integration of all networks (see the issue with D2D above)
- **Network *robustification***
  - No increase of bit-rate, a huge improvement of user experience, indistinguishable in mobility from that on the fixed network

- We are not saying that research in 5G is over – but we've probably entered a phase where development is dominant over fundamental research
  - So true, that the EC through 5GPPP has pushed towards a strong industrial perspective of activities in H2020
- Within 5GPPP (or parallel to that), the word of Academia and the laboratories involved in fundamental technologies expect an early start of some concrete B5G policy-making and actions
  - So that more fundamental research pairs current R&D in paving the way for B2020

- Europe has the lead in the field of cooperative research
  - It is something whose value comes from the "pooling" of knowledge and resource that has to be pursued further and further in future programs
- If Europe has to keep the lead, in spite of the many changes involving the main players in the field, the only way is to think forward and try to anticipate the new technologies as much as possible
  - In the past, it worked in many areas: 2G, (to some extent)3G, 4G, DVB for broadcasting etc.
- Even non-European players will welcome advances in (European) fundamental research
  - This has already happened – many of the features embedded into 4G, are a results of fundamental technologies devised in Europe

- **All of the previous statements about leadership are easier said than done**
  - SMEs are often at the forefront, but their research fails to achieve a critical mass
  - The same is true for Academia, whose relation with large companies is at times too weak – we're even witnessing cases of diaspora of researchers from University to companies
  - At times, large companies may be medium-term oriented with lesser attention to fundamental aspects

The times of large National laboratories (like CSELT…) are well over and unfortunately we do not have a CERN for wireless communications to steer and implement research at the continental level

Federative actions are still needed to make available to the community shared resources and facilities for fundamental theoretical and experimental research

- There is a lot (still) to be done in the area of radio access, especially in the fields of cooperative and non-cellular communications
  - Something that we may start qualifying as "Beyond 5G"
- 5GPPP has already identified the main trends and projects that are needed to come to successful architecting of 5G
  - It will smoothly hand over to standardization bodies (or will be directly turned into one?)
  - Fundamental research risks having (only) an indirect role into the different projects that are envisaged

- Together with short-to medium term activities, the EC should find a direct way to support fundamental research to help European companies and Institutions keep the edge
  - Fundamental does not only mean theoretical. In engineering, fundamental can have both a theoretical and an experimental flavor
  - The instruments to do this has probably to be refined (including NoEs…)
  - SO FIND A KILLER IDEA, BUILD A NEW LABORATORY FOR B2020, AND CALL IT

ICT9 – 2017: Networking research beyond 5G

Specific Challenge:

While 5G networks has an established roadmap towards technology validation, specifications and tests by industry, outstanding new scientific opportunities are blooming in the field of networking research, with the objective of bringing little explored technologies and system concepts closer to exploitation. The challenge is to support European scientific excellence notably in the DSP domain, and to bring the most promising long term research coming from the labs closer to fruition. This includes perspectives for the full exploitation of the spectrum potential, notably above 90Ghz, with new waves of technologies and knowledge, bringing wireless systems to the speed of optical technologies, and for new applications. It includes interaction with photonic systems as well as new cooperation networking and protocols, notably in the mobility context.

Development and exploitation of academic research through transfer and innovation towards industry with a particular focus on SMEs is an integral part of the challenge.

6.5 Annex V: Publications in Year 3

Nr	Journal Papers – Joint	WP
1	A. Shams, B. Lorenzo, S. Glisic, J. Perez-Romero, L. DaSilva, A. Mackenzie, J. Roning, A framework for Dynamic Network Architecture and Topology Optimization. IEEE/ACM Transactions on Networking, January 2015	1.2
2	E. Arıkan, N. ul Hassan, M. Lentmaier, G. Montorsi and J. Sayir, Challenges and some new directions in channel coding, Journal of Communications and Networking, JOURNAL OF COMMUNICATIONS AND NETWORKS, 30 August 2015, Vol. 17, No. 4	1.1
3	M. El Soussi, A. Zaidi and L. Vandendorpe, Compute-and-Forward on a Multi-User Multi-Relay Channel" IEEE Wireless Communications Letters, Vol. 03, No. 06, December 2014, pp. 589-592	1.2
4	S. D'Oro, L. Galluccio, G. Morabito, S. Palazzo, L. Chen, F. Martignon, Defeating jamming with the power of silence: a game-theoretic analysis, IEEE Transactions on Wireless Communication, vol.14, no.5, pp.2337-2352, May 2015	1.2
5	E. Bjornson, L. Sanguinetti, M. Kountouris, Deploying Dense Networks for Maximal Energy Efficiency: Small Cells Meet Massive MIMO, IEEE J. Select. Areas Commun., to appear (accepted Oct. 2015).	1.1
6	M. El Soussi, A. Zaidi and L. Vandendorpe, DF-based Sum-rate Optimization for Multi-carrier Multiple Access Relay Channel, Eurasip Journal on Wireless Communications and Networking , May 2015.	1.2
7	J. Matamoros, S. M. Fosson, E. Magli, C. Antón-Haro,, Distributed ADMM for in-network reconstruction of sparse signals with innovations, To appear in IEEE Transactions on Signal and Information Processing over Networks, September 2015.	1.2
8	G. Bacci, E.V. Belmega, P. Mertikopoulos, and L. Sanguinetti, Energy-Aware Competitive Power Allocation for Heterogeneous Networks Under QoS Constraints,Wireless Communications, IEEE Transactions on, Volume:14 , Issue: 9, April 2015	1.3
9	A. Zappone, L. Sanguinetti, G. Bacci, E. Jorswieck, M. Debbah, Energy-Efficient Power Control: A Look at 5G Wireless Technologies, To appear in IEEE Trans. Signal Processing, Sept. 2015.	1.3
10	G. Bacci, S. Lasaulce, W. Saad, L. Sanguinetti, Game Theory for Signal Processing in Networks, IEEE Signal Processing Magazine, To appear (accepted June 2015)	1.3
11	C. Tian, B. Bandemer and S. Shamai (Shitz), Gaussian State Amplification with Noisy Observations, IEEE Trans. on Information Theory, vol. 61, no. 9, pp. 45874597, Sept. 2015.	1.1
12	D. Dardari, P. Closas, P. Djuric, Guest Editorial Special Section on: Indoor localization, tracking, and mapping with heterogeneous technologies, IEEE Trans. on Vehicular Technology, Vol. 64, No. 4, pp. 1261-1262, 2015.	2.1
13	D. Dardari, P. Closas, P. Djuric, Indoor tracking: Theory, Methods, and Technologies, IEEE Trans. on Vehicular Tech., Vol. 64, No. 4, pp. 1263-1278, 2015.	2.1
14	L. Sanguinetti (CNIT-Pisa), A. Moustakas (IASA), M. Debbah (SUPELEC), Interference Management in 5G Reverse TDD HetNets with Wireless Backhaul: A Large System Analysis, IEEE Journal on Selected Areas in Communications, special issue on Recent Advances in Heterogeneous Cellular Networks , to appear 2nd quarter, 2015.	1.1
15	S. D'Oro, P. Mertikopoulos, A. L. Moustakas, S. Palazzo, Interference-based pricing for opportunistic multi-carrier cognitive radio systems, to appear in IEEE Transactions on Wireless Communications, 2015. DOI: 10.1109/TWC.2015.2456063.	1.2

16	L. Sanguinetti (CNIT-Pisa), A. Moustakas (IASA), E. Bjornson, M. Debbah (Supelec), Large System Analysis of the Energy Consumption Distribution in Multi-User MIMO Systems with Mobility, IEEE Transactions on Wireless Communications, vol. 14, no. 3, March 2015, pp. 1730-1745, ISSN 1536-1276, DOI 10.1109/TWC.2014.2372761	1.1
17	A. Zaidi and Shlomo Shamai (Shitz), On Cooperative Multiple Access Channels with Delayed CSI at Transmitters, IEEE Trans. Information Theory, vol. 60, no. 10, pp. 6204-6230, Oct. 2014.	1.1
18	L. Galluccio, B. Lorenzo, S. Glisic., On the Impact of Sociality in Multicast DTNs with Adaptive Infection Recovery. IEEE Transactions on Vehicular Technology, April 2015	1.2
19	J. Pérez-Romero, A. Zalonis, L. Boukhatem, A. Kliks, K. Koutlia, N. Dimitriou, R. Kurda, , On the use of Radio Environment Maps for Interference Management in Heterogeneous Networks, IEEE Communications Magazine, August, 2015, pp. 184-191	1.3
20	I. Stupia, L. Sanguinetti, G. Bacci, L. Vandendorpe, Power Control in Networks With Heterogeneous Users: A Quasi-Variational Inequality Approach, IEEE Trans. Signal Process., vo. 33, no. 21, Oct. 2015	1.3
21	I. Sugathapala, I. Kovacevic, B. Lorenzo, S. Glisic, Y. Fang, Quantifying Benefits in a Business Portfolio for Multi-Operator Spectrum Sharing. IEEE Transactions on Wireless Communications, July 2015	2.3
22	L. Galluccio, B. Lorenzo, S. Glisic, Sociality-aided new adaptive infection recovery schemes for multicast DTNs, to appear in IEEE Transactions on Vehicular Technology, 2015.	1.2
23	A. Kliks, O. Holland, A. Basaure, M. Matinmikko, Spectrum and licence flexibility for 5G networks, To appear in IEEE Communications Magazine, 2015.	1.3
24	A. Mallat, S. Gezici, D. Dardari, L. Vandendorpe, Statistics of the MLE and Approximate Upper and Lower Bounds–Part II: Threshold Computation and Optimal Pulse Design for TOA Estimation, IEEE Transactions on Signal Processing, vol.62, no.21, pp. 5677-5689, Nov., 2014.	2.1
25	C. Buratti, A. Stajkic, G. Gardasevic, S. Milardo, M. D. Abrignani, S. Mijovic, G. Morabito, R. Verdone , Testing protocols for the Internet of Things on the EuWIn platform, to appear in IEEE Internet of Things Journal, 2015.	2.2

Nr	Conference Papers - Joint	WP
1	J. Matamoros, S. M. Fosson, E. Magli, C. Antón-Haro, A distributed ADMM Scheme for the Reconstruction of Jointly Sparse Signals with Sensor Networks, Joint NEWCOM#/COST IC1004 Workshop (JNCW'15), Barcelona (Spain), October 2015.	1.2
2	A. Zappone (TUD), L. Sanguinetti (CNIT-Pisa), G. Bacci (CNIT-Pisa), E. Jorswieck (TUD), M. Debbah (Supelec), A Framework for Energy-Efficient Design of 5G Technologies, IEEE International Conference on Communications (ICC 2015), London, UK, June 8-12, 2015.	1.3
3	Mingming Gan, Zhinan Xu, Markus Hofer, Gerhard Steinböck, Thomas Zemen, A Subband Divided Ray Tracing Algorithm Using the DPS Subspace in UWB Indoor Scenarios, Proc. 2015 IEEE 81th Vehicular Technology Conference (VTC Spring 2015), 11–14 May 2015.	2.1
4	G. Rodríguez, M. Nájar, M. Navarro, Adaptive real-time detection algorithms for respiratory patterns based on UWB radar, Joint NEWCOM#/COST IC1004 Workshop (JNCW'15), Barcelona (Spain), October 2015.	2.1
5	J. M. Castro-Arvizu, A. Moragrega, P. Closas, J. A. Fernández-Rubio, Assessment of RSS Model Calibration with Real WLAN Devices, in Proc. of the IEEE International Symposium on Wireless Communication Systems (ISWCS 2015), 25-28 August 2015, Brussels	2.1

	(Belgium).	
6	X. Mestre, P. Vallet, W. Hachem, Asymptotic Analysis of Linear Spectral Statisitcs of the Sample Coherence Matrix, in Proc. IEEE Int'l Conference on Audio Speecn and Signal Processing (ICASSP 2015), Brisbane (Australia), April 2015.	1.2
7	M. Benammar, P. Piantanida and S. Shamai (Shitz), Capacity Results for the Multicast Cognitive Interference Channel, IEEE Information Theory Workshop (ITW2015), April 26-May 1, 2015, Jerusalem, Israel	1.1
8	S. D'Oro, P. Mertikopoulos, A. L. Moustakas, S. Palazzo, Cost-efficient power allocation in OFDMA cognitive radio networks, Proc. EUCNC 2015, European Conference on Networks and Communications, June 29-July 2, 2015, Paris, France.	1.2
9	ARVANITAKIS George, KALTENBERGER Florian, Dagres, Ioannis, Polydoros, Andreas, Kliks, Adrian, Cramer Rao lower bound for multi-source localization in spatial correlated environment, EUCNC 2015, European Conference on Networks and Communications, June 29-July 2, 2015, Paris, France	2.3
10	J. M. Castro-Arvizu, P. Closas, J. A. Fernández-Rubio, Cramér-Rao lower bound for breakpoint distance estimation in a path-loss model, in Proc. of the IEEE International Conference on Communications (ICC 2014), 10-14 June 2014, Sidney (Australia).	2.1
11	A. F. Abdelkader, J. Pérez-Romero, A. Umbert, F. Casadevall, A. Kliks, P. Kryszkiewicz, Deployment of Indoor LTE Small Cells in TV White Spaces, Joint NEWCOM/COST Workshop on Wireless Communications JNCW 2015, Barcelona, October, 2015	1.3
12	E. Bjornson, L. Sanguinetti, M. Kountouris, Designing Wireless Broadband Access for Energy Efficiency: Are Small Cells the Only Answer?, International Conference on Communications (ICC), London, UK, June 2015.	1.1
13	S. M. Fosson, E. Magli, J. Matamoros, C. Antón-Haro, Distributed algorithms for in-network recovery of jointly sparse signals, Proc. Signal Processing with Adaptive Sparse Structured Representations, Cambrdige (UK), July 6-9, 2015.	1.2
14	A. Zappone, L. Sanguinetti, G. Bacci, E. Jorswieck, M. Debbah, Distributed Energy-Efficient UL Power Control in Massive MIMO with Hardware Impairments and Imperfect CSI, International Symposium on Wireless Communication Systems (ISWCS), Brussels, Belgium, Aug. 2015	1.3
15	G. Pichler, P. Piantanida, and G. Matz, Distributed Information-Theoretic Biclustering of Two Memoryless Sources, in Proc. Allerton Conf. on Communication, Control, and Computing, Sept.-Oct. 2015, Monticello (IL)	1.1
16	Sophie Fosson,Javier Matamoros,Carles Anton-Haro, Enrico Magli, Distributed support detection of jointly sparse signals, in Proc. IEEE Int'l Conference on Audio Speech and Signal Processing (ICASSP 20154, Florence (Italy), May 2014.	1.2
17	Paweł Kryszkiewicz, Adrian Kliks, and Krzysztof Cichoń, Anna Umbert, Jordi Perez-Romero, Ferran Casadevall, DVB-T channels measurements for the deployment of outdoor REM databases', Joint NEWCOM/COST Workshop on Wireless Communications JNCW 2015, Barcelona, October 2015.	2.1
18	E. Bjornson, L. Sanguinetti, M. Kountouris, Energy-Efficient Future Wireless Networks: A Marriage between Massive MIMO and Small Cells, The 16th IEEE International Workshop on Signal Processing Advances in Wireless Communications (SPAWC15), Stockholm, Sweden, June 2015.	1.1
19	L. Galluccio, C. Giannini, B. Lorenzo, S. Glisic, C. Buratti, R. Verdone, Epidemic information dissemination in opportunistic scenarios: a realistic model obtained from experimental traces, International Symposium on Wireless Communication Systems (ISWCS), Brussels, Belgium, Aug. 2015	1.2

20	Kaltenberger, Florian, Knopp Raymond, Danneberg, Martin, Festag, Andreas, Experimental analysis and simulative validation of dynamic spectrum access for coexistence of 4G and future 5G systems, EUCNC 2015, European Conference on Networks and Communications, June 29-July 2, 2015, Paris, France	2.3
21	Florian Kaltenberger and Raymond Knopp and Carmine Vitiello and Martin Danneberg and Andreas Festag, Experimental Analysis of 5G Candidate Waveforms and their Coexistence with 4G Systems, Joint NEWCOM/COST Workshop on Wireless Communications JNCW 2015, Barcelona, October 2015.	2.3
22	O. Font-Bach, N. Bartzoudis, D. López, E. Vinogradov, M. Payaro, C. Oestges, T. Andre Myrvoll, V. Ringset, Experimental performance evaluation of a 5G spectrum sharing scenario based on field-measured channels, IEEE Annual International Symposium on Personal Indoor and Mobile Radio Communications (PIMRC), August 30-September 2, 2015, Hong Kong (China).	2.1
23	B. Lorenzo, I.Kovacevic, F. J. Gonzalez-Castano, J.C. Burguillo, Exploiting Context-Awareness for Secure Spectrum Trading in Multi-hop Cognitive Cellular Networks. Accepted for presentation at IEEE Globecom Workshops 2015	1.2
24	Del Fiorentino, P.; Van Hecke, J.; Lottici, V.; Giannetti, F.; Moeneclaey, M.,, Goodput-based Resource Allocation and DF Relay Selection for Dual-Hop Transmissions with Packet-oriented Cognitive BIC-OFDM Systems, in the Proceedings of Joint NEWCOM/COST Workshop on Wireless Communications (JNCW 2015), Barcelona, Spain, October 14-15, 2015.	1.3
25	Jeroen Van Hecke (UGent), Paolo Del Fiorentino (CNIT-Pisa), Riccardo Andreotti (CNIT-Pisa), Vincenzo Lottici (CNIT-Pisa), Filippo Giannetti (CNIT-Pisa), Luc Vandendorpe (UCL), Marc Moeneclaey (UGent), Goodput-maximizing Resource Allocation in Cognitive Radio BIC-OFDM systems with DF Relay Selection, IEEE International Conference on Communications (ICC 2015), London, UK, June 8-12, 2015.	1.3
26	J. Matamoros, C. Antón-Haro, S. M. Fosson, E. Magli, In-network reconstruction of correlated sparse signals with innovations, Wireless World Research Forum 34, Santa Clara (California), April 21-23, 2015. Invited.	1.2
27	J. Matamoros, S. M. Fosson, E. Magli, C. Antón-Haro, In-network reconstruction of jointly sparse signals with ADMM, European Communications and Networking Conference, Paris (France), June 29-July 2, 2015.	1.2
28	W. Li, F. Bassi, D. Dardari, M. Kieffer, G. Pasolini, Iterative Distributed Outlier Detection for Wireless Sensor Networks: Equilibrium and Convergence Analysis, Proc. IEEE Conference on Decision and Control, 2015.	1.3
29	W. Li, F. Bassi, D. Dardari, M. Kieffer, G. Pasolini, Low-Complexity Distributed Fault Detection for Wireless Sensor Networks, Proc. IEEE International Conference on Communications, London, 2015	1.2
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