IRACON

COST CA15104 ACTION

Newsletter

Inclusive Radio Communication Networks for 5G and Beyond

Number 12, March 2020

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About COST IRACON

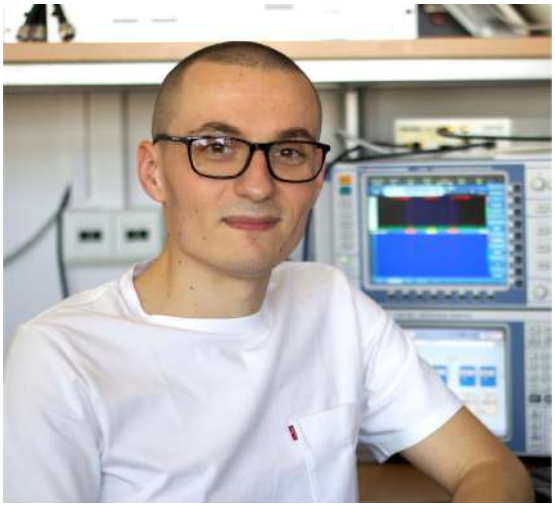
This COST Action IRACON (Inclusive Radio Communications) aims at scientific breakthroughs by introducing novel design and analysis methods for the 5th-generation (5G) and beyond-5G radio communication networks. Challenges include i) modelling the variety of radio channels that can be envisioned for future inclusive radio, ii) capacity, energy, mobility, latency, scalability at the physical layer and iii) network automation, moving nodes, cloud and virtualisation architectures at the network layer, as well as iv) experimental research addressing Over-the-Air testing, Internet of Things, localisation and tracking and new radio access technologies. This COST Action started on March 2016 and will end in March 2020.

http://www.iracon.org

cost EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

COST is supported by the EC H2020 Framework

Editor's Address



Piotr Rajchowski
Gdańsk University of Technology, Poland

Dear reader,

I am glad to introduce you the twelfth issue of this newsletter. In this issue, we focus on the highlights of our 12th, the last, technical meeting of the Iracon action, which took place in Louvain-le-Neuve, Belgium. The meeting was joined with the one day IRACON Final Workshop.

As usual, we'd like you to meet two people behind the Action. In this issue, we have given the floor to Gordana Gardašević, professor at the University of Banja Luka, Bosnia and Herzegovina (UNIBL), and to Dr. Gerhard Steinböck, from the Huawei Sweden AB.

We hope that this newsletter and experience gathered during the Action will inspire you for an innovative and fruitful research.

Enjoy the reading!

Chairman's Address

Claude Oestges
Université catholique de Louvain, Belgium

Dear IRACON colleagues,

I am writing this last address as IRACON Chair with mixed feelings. Of course, I am proud of what IRACON, that is all of you, has achieved over the last four years. At the same time, I would have liked to conclude the Action within a much more optimistic international context than our kick-off meeting. Unfortunately, this was not to be the case. Whereas our kick-off took place during the terrorist attacks in Brussels, our last day (March 21, 2020) was marked by confinement and lock-down in many places all over Europe and the world. Let me first express the hope that all of us are safe and well in these worrying days. To all of you who read these lines from home, let me add that tomorrow will definitely be better than today. Because there will be times again when we will be free to meet face-to-face, discuss without headphones and webcam and carry out short-term exchanges and experimental works. In such period, we do realise what COST (not only IRACON, but also all previous Actions on radio-communications) has brought us: the feeling that we are indeed a community.

Personally, I am infinitely grateful to all MC members and participants for their continuous trust and their significant commitment to IRACON. Chairing such an Action has not been an easy task, but your involvement and enthusiasm have remained incredible: the number of contributions, training schools, short-term missions, etc. is a clear proof of our successes. As I mentioned during our final workshop in Louvain-la-Neuve, a very big thank to you!

Although IRACON officially ended on March 21, 2020, the work is actually not over: our final book needs to be finalised and IRACON special sessions are still planned in the coming months. As you also know, some of our experts have submitted a COST Innovators' Grant application to build a bridge between the scientific research performed in IRACON and a marketable product.

I hope to meet you again in the near future. Take care of yourself and your family,

Claude Oestges

IRACON Final Workshop, 28 January 2020, Louvain-la-Neuve, Belgium

Radio Communications have become one of the pillars on which our Society relies for performing many daily tasks. Today, the number of connected devices is increasing exponentially, reflecting not only enthusiastic smartphone adoption but also increasing connectivity of machines, sensors, vehicles and other devices for health and smart environments. The Inclusive Radio Communications concept defines those technologies aimed to support wireless connectivity at any rates, for any communicating units, and in any type of scenarios. The Wireless Internet of Things beyond 2020 requires revolutionary approaches in Radio Access technologies, networks and systems.

Over its four years of existence, COST Action CA15104 (IRACON) has achieved scientific breakthroughs by introducing novel design and analysis methods for the 5th-generation (5G) and beyond-5G radio communication networks. Results have spanned the whole gamut from radio channel modelling, in particular in the millimetre-wave range to signal processing for massive MIMO and C-RAN, innovative network architectures and protocols and finally experimental research addressing Over-the-Air testing, the Internet of Things, localisation and tracking and new radio access technologies. The IRACON Final Workshop brought together several international experts to discuss new emerging challenges in the scientific areas covered by the Action.

Workshop Organiser:
Claude Oestges, Université Catholique de Louvain

Workshop sessions:
Future Internet-of-Things and its Applications
PHY Layer and Cellular Radio: Trends and Challenges
Intelligent Radio Networks
Smart Mobility and Positioning

URL: http://www.iracon.org/workshops/iracon-final-workshop/

Interview with a senior researcher

Gordana Gardašević

Associate Professor, University of Banja Luka, Bosnia and Herzegovina

Short biography

Prof. Gardašević received her PhD in Telecommunications in 2008 from the Faculty of Electrical Engineering, University of Banja Luka (UNIBL), Bosnia and Herzegovina. In 2014, she was a Visiting Postdoctoral Fellow at Radio Networks Group, University of Bologna. Since 2014 she has been an Associate Professor at UNIBL. Prof. Gardašević published three books and one monograph, as well as more than 70 research papers. She is a member of the IEEE.

What was your motivation to become a researcher?

Being a researcher opens up an exciting new horizon of innovations and challenges. This is a dynamic field and searching for solutions is a process of learning and exploring the world around us.

What are your favourite areas of interest and research?

Industrial Internet of Things (IoT) protocols and applications, next-generation networks architectures, cross-layer protocol design, wireless sensor networks.

What was your motivation to be part of COST IRACON?

I have to say that it has been a great privilege and an honour to work with such an extraordinary IRACON family! I do consider this group as a family because apart form networking and common research activities, we do create an inspiring and friendly environment for collaboration. As I am coming from the country with poor infrastructure and technological resources, the IRACON has provided many possibilities and tools for research.

What would like COST IRACON to achieve?

I would like to see the continuation of IRACON activities in the future, as I consider this action as very successful and valuable.

Considering the innovations in the scientific world in the last 20 years, which was the most remarkable one, which one didn't get the attention it deserved?

Smartphones and social networks have dramatically influenced our everyday lives. I would also emphasise the importance of healthcare applications and their impact on the quality of life. We have to force the use of eco-friendly technologies in order to save our planet. On the other side, there are a number of communication devices, software applications, and technologies that came to "dead-end" due to the explosive progress.

How did you became involved in COST IRACON (or any of the previous Actions)?

I got the invitation from my colleagues based on our research collaboration.

What is the "next big thing" in the wireless communication area?

In my opinion, the key enabler is the convergence that has transformed the traditional ICT (Information and Communications Technologies) ecosystem by cross-industry and cross-sector collaboration. Now, we are approaching the new industrial age where the emerging wireless technologies, artificial intelligence, data analytics, and IoT will shape the future of communications. We will see new applications (e.g. holographic type communications), new methods of transmitting information, new energy-efficient technologies, and a true fusion of digital and real worlds.

In a few words, I consider myself to be…

I consider myself to be a fortunate person because I am living in this exciting and turbulent 21st century, with enormous advancements in science and technology.

What is your country well known for?

Warm and hospitable people, novelist Ivo Andrić who won the Nobel Prize in Literature, great biodiversity, historic towns, food.

The habit I don't have and what I like most is …

Spending more time outside the urban borders, possibly on the seacoast.

My favourite or personal quote is …

People are interconnected by invisible forces. Although we have the freedom to think and act, we stick together, like stars on the heavenly arc, with unbreakable connections. These connections cannot be seen, but we can feel them [Nikola Tesla].

Interview with an Early Career Investigator

Gerhard Steinböck
PhD, Huawei Sweden AB

Short biography

After studying at University of Applied Sciences Technikum Wien, he worked at ARC Seibersdorf, now known as Austrian Institute of Technology AIT on real time channel emulators. After approx. 7 years of working at AIT he moved abroad to study at Aalborg University in Denmark, where he did Msc. and Phd Degrees in Wireless Communications. After 2 years of Post Doc, he joined Huawei Sweden AB, in 2016 where he works as a base station systems engineer with focus on radio propagation.

What was your motivation to become a researcher?

Curiosity and trying to understand more.

What are your favourite areas of interest and research?

Radio propagation, parameter estimation and channel modelling in various frequency bands and for communications, localisation and radar.

How did you became involved in COST IRACON (or any of the previous Actions)?

During my past work on real time channel emulation, I got to know the geometric stochastic channel models of COST 259 and COST 273 and around that time I joined the first few times COST meetings at COST273. Since then I believe that these COST actions are simply fantastic when it comes to the networking possibilities, the great researchers, the concentrated knowledge and in particular the willingness of everybody to provide constructive feedback, to share knowledge and to collaborate.

Considering the innovations in the scientific world in the last 20 years, which was the most remarkable one, which one didn't get the attention it deserved, and which one finished with a "dead end"?

I'm a bit biased, I think the improved understanding of the characteristics of the wireless channel is great. It led to "smart antennas", MIMO and now to MA-MIMO, where we finally make use of the potential of the channels characteristics for communications purposes.
Several years ago, there was a hype around "green communications". Lots of research was done during that period with respect to energy consumption and power savings in ICT. I believe we still need to tackle that problem and should strive to reduce the energy consumption for the sake of future generations.
I do not think that anything can finish with a "dead end". We always learn and mostly from things that appear to be a "failure".

What is the "next big thing" in the wireless communication area?

"Shaping the wireless channel" for communication purposes. May it be with intelligent reflective surfaces, with distributed MIMO or MA-MIMO systems, super large MA-MIMO systems (active or passive) over entire building facades, etc.

What was your motivation to be part of COST IRACON?

It is a great network opportunity and allows one to keep track of research ongoing in many European Universities.

I'm most passionate about...

I'm passionate about old vintage Vespa scooters. I like their design, a bit of repairing, getting your hands dirty and of course driving around with other enthusiasts in Denmark and Sweden.

My favourite holiday is…

Christmas. Since I now have been for 4 years in Sweden and before that 10 years in Denmark, I like that for Christmas I visit my family and friends both in Austria and in Denmark.

My favourite (non-scientific) book, music(ian), movie, TV series are …

After starting watching the Game of Thrones on TV I got hooked on the books too and in general I like fantasy novels. With respect to music I'm stuck in the 90's rock, punk, grunge, etc. And right now, I like to watch the old and new Star Trek shows "Discovery" and "Picard".

What is your country well known for?

I guess my home country Austria is famous for classical music and probably "Wiener Schnitzel" and "Sacher Torte". My second home country, Denmark, is well known for the long sandy beaches with a constant fresh breeze of wind and of course, their windmills for electricity generation. As I'm currently living in Sweden I would say it is Greta Thunberg, Volvo.

Selected scientific topic:

"Mobile propagation channel comparison at 3.7 GHz and 17.5 GHz in urban macro- and microcell environments" Jean-Marc Conrat - TD(20)12004

Analysing propagation channel frequency-dependence is a major issue for the 5G and beyond 5G wireless systems as higher frequencies such as millimetre waves are proposed in order to increase the data rate. The TD presents a comparison between mobile propagation channels at 3.7 GHz and 17.5 GHz in macro and microcell environments. The study is based on measurement data extracted from a drive-test-like measurement campaign performed in Belfort, France. Transfer functions defined with a 200 MHz bandwidth were collected in a various urban environments. Metrics such as the path loss or the delay spread were calculated. The data analysis conducted through space-time power profiles visual inspection or channel metric statistical distribution indicates that the propagation channel structures at 3.7 GHz and 17.5 GHz are very similar. The average path loss differences between both frequencies calculated for different environment (dense urban, suburban, etc), for different BS antenna heights (macro = 25 m, micro = 5 or 10 m) and propagation conditions (LOS, NLOS, etc) are close to the theoretical free space reference and equal to 20^{*}Log_{10}(frequencies ratio).

Table: Mean DS and path loss difference (NLOS).

	Delay spread [ns]		Path loss diff. [dB]
	3.7 GHz	17.5 GHz	
Micro 5 m	93	96	13.1
Micro 10 m	111	109	13.2
Macro 25 m	170	170	12.4

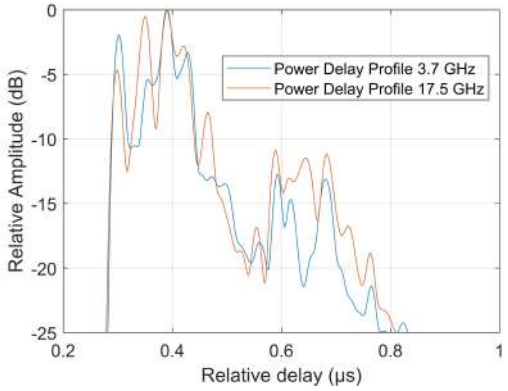


Figure: Normalised Power Delay Profiles.

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Selected scientific topic:

"Channel Extrapolation in FDD Massive MIMO: Theoretical Analysis and Numerical Validation" François Rottenberg, Rui Wang, Jianzhong Zhang and Andreas F. Molisch - TD(20)12008

Downlink channel estimation in massive multiple-input-multiple-output systems is well known to generate a large overhead in frequency division duplex mode as the amount of training generally scales with the number of transmit antennas. Using instead an extrapolation of the channel from the measured uplink estimates to the downlink frequency band completely removes this overhead. In this paper, we investigate the theoretical limits of the channel extrapolation in a frequency. We highlight the advantage of basing the extrapolation on high-resolution channel estimation. A lower bound (LB) on the mean squared error (MSE) of the extrapolated channel is derived. A simplified LB is also proposed, giving physical intuition on the SNR gain and extrapolation range that can be expected in practice. The validity of the simplified LB relies on the assumption that the paths are well separated. The SNR gain then linearly improves with the number of receive antennas while the extrapolation performance penalty quadratically scales with the ratio of the frequency and the training bandwidth. The theoretical LB is numerically evaluated using a 3GPP channel model and we show that the LB can be reached by practical high-resolution parameter extraction algorithms. Our results present that there are strong limitations on the extrapolation range than can be expected in SISO systems while much more promising results can be obtained in the multiple-antenna setting as the paths can be more easily separated in the delay-angle domain.

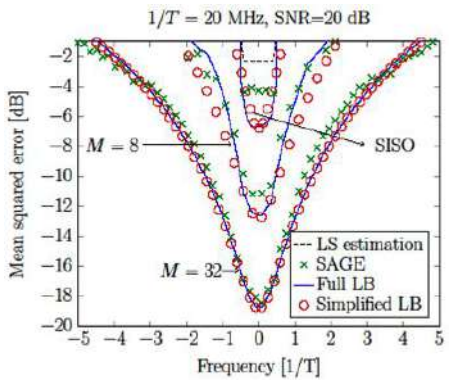

Figure: Illustration of different algorithms performance.

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Selected scientific topic:

"Physical Modeling for Device-Free Localisation exploiting Multipath Propagation of Mobile Radio Signals" Martin Schmidhammer, Michael Walter, Christian Gentner, Stephan Sand, TD(20)12014

With smart environments, such as modern manufacturing facilities and smart homes, the demand for location-aware applications is steadily increasing. Typically this demand is served by active RF-based localisation systems that require the user to carry a tracking device. Alternatively, novel passive localization systems estimate the position of the user through measuring the user's effects on the RF signals of a wireless sensor network. Here, the user does not need to carry any device, i.e. the demand is served by a device-free localisation system.

Such a systems strongly rely on the underlying models describing the impact of the user on the RF signal propagation to estimate the user's position. Hence, in this work, we introduce a novel model to describe the impact of a user on the received power of multipath components. We describe how to apply the scalar theory of diffraction to calculate the impact of a user on the electric field. We evaluate the model with a wideband measurement data (measurement stand is presented in the Figure). Comparing the modelled attenuation results with the measurement data qualitatively confirms that the estimated attenuation values induced by the user match the measured attenuation values. Thus, the novel physical propagation model enables accurate device-free localisation. Further, incorporating multipath components in device-free localisation allows position estimation with less dense wireless sensor networks.

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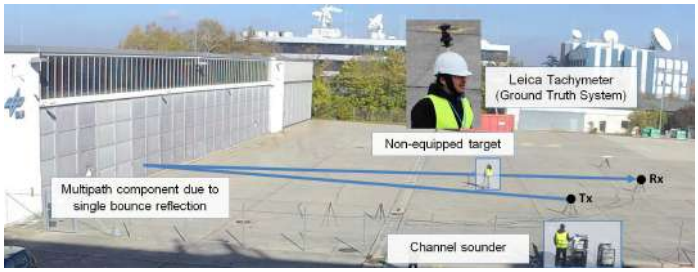

Figure: Channel sounder setup to measure the received signal power of a dedicated multipath component due to single bounce reflection. Measurement data are used to validate the proposed physical model, which describes the impact of persons on the received power of multipath components.

Selected scientific topic:

"Beam Selection for Hybrid Beamforming with Multi-Path Propagation: Novel Learning Architectures and Sufficient Statistics" Carles Antón-Haro, Xavier Mestre, TD(20)12045

In this work, we investigate the applicability of the deep and machine learning (ML/DL) techniques to the beam selection problems. Specifically, we adopt a hybrid beamforming architecture comprising an analog beamforming (ABF) network followed by a zeroforcing (ZF) baseband processing block. The goal is to select the element in the ABF codebook yielding the highest sum-rate. The multi-antenna system operates in the 5GNR's Frequency Range 2 and, accordingly, the ML/DL-based architecture has been designed to explicitly consider a number of practical aspects of such mmWave communication systems. In particular, the presence of multi-path propagation along with the use of multi-carrier signals precludes the application of (single) angle-of-arrival information as an input to the learning system. Therefore, we investigate here an alternative sufficient statistics (SS) such as the singular vector/values of the (multi-carrier) channel matrix, the average covariance matrix, or the covariance matrix at a given subcarrier.

Besides, the novel ML/DL architecture enables a continuous operation of the system and avoids the spectral efficiency losses associated to the periodically switching to a dedicated ABF for SS estimation. Computer simulation results illustrate the performance of the several ML/DL approaches (k-nearest neighbours, support vector classifiers, multi-layer perceptron) in realistic 5G scenarios.

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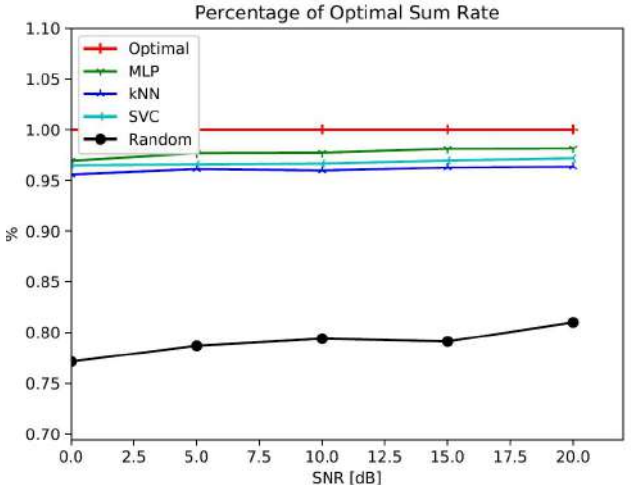


Figure: Percentage of the sum-rate for each ML/DL method vs. signal to-noise ratio.

Highlights from the last meeting

DWG1 - Radio channels: DWG1 sessions covered 19 TDs. They were focussed on a new channel simulations and measurement campaigns with strong interest to understand the channel behavior for a various use scenarios. The measurements include multi-frequency comparison, material parameter estimation, vehicular and drone channels, building entry loss and clutter loss. Analysis of vegetation to the link shadowing, electromagnetic scattering effects and efficient implementation of ray-tracing were also presented. Finally, signal processing methods for improved channel modeling were discussed, including new clustering and channel parameter estimation methods. A related topic was a smart surfaces that direct energy to non-specular directions realised through for example a transmit array.

DWG2 - PHY (Physical) Layer: WG2 had 2 sessions attended by a surprisingly high number of 34 attendees. The topics covered areas of broadcast beamforming fundamental limits analysis for M-MIMO, M-MIMO FDD channel state estimation extrapolation, which is based on path resolution, stochastic geometry modeling for UAV (Unmanned Aerial Vehicle) relay network and a power allocation in partial NOMA. A number of papers focused on an application of machine learning and artificial neural network in communication scenarios. Particularly these works were a beam selection using the SVD (Singular Value Decomposition) sufficient statistics and ML/ANN (Multi Layer Artificial Neural Network) solver, and deep-learning in decoding of channel codes.

DWG3 - NET Layer: Four TDs were discussed at the WG3 sessions covering the analysis of 3D Deafness effects in highly directional mmWave communications, real-time QoS-demand-aware computational resource sharing optimisation in C-RAN (Cloud-Radio Access Networks), theoretical and emulated performances of MANETs with TDMA and an automatic method to obtain the QoS thresholds in several analytical QoE models using the LTE collected traces.

EWG-RA Radio Access and DWG3 - NET (Network): During the meeting 5 TDs were presented. They covered measurement path loss versus models from standards for both LTE and NR (New Radio) frequency bands, analysis of renewable energy sources for LTE base stations, ground to air channel measurements for unmanned freight flights at C-band, cost analysis for small 5G cell deployments and finally waveform selection for 5G NR use cases. For our last speaker, 3 months in to his PhD, this was his first COST IRACON meeting, but hopefully not his last one!

EWG-OTA - Over-The-Air testing: In TD(20)12022, renewed attention was drawn to the advantages of an alternative to the conventional channel description by specular paths with unresolved dense multipath. This approach dates back to COST2100 (2007-2010). Embedding or de-embedding antennas (whose patterns are often specified in terms of spherical vector harmonics) into/out of an antenna-independent channel description is simple when the channel is characterised by spherical harmonics too. The channel matrix is in this case interpreted as a mode-coupling matrix with the optimal choice of antenna patterns being the one that matches the dominant couplings in the channel. The problem with angular resolution, compare with dense multipath in the plane-wave description, remains. In the spherical harmonics domain, it manifests itself in not being able to measure all modes present in the channel as well as in the antennas not exciting non-dominant modes, in terms of lost received power.

EWG-IoT - Internet-of-Things: In the EWG on IoT a work on LOS/NLOS detection was presented using the Long Short-Term Memory to take advantage of data from previous timestep. Another work investigated how to plan the trajectory of an unmanned aerial vehicle to serve fixed IoT nodes. Finally, a sensor fusion for cooperative radars in a road vehicular setting was presented. Additionally, a particle filters were shown to yield significantly improved accuracy. During the meeting no dedicated session of the SEWG-IoT - Internet-of-Things for Health was held.

EWG-LT - Localisation and Tracking: Four TDs were presented providing new insights in the 5G-based localisation using polynomial chaos expansion, models to describe the impact of a target on the received power of a multipath component, novel localisation strategies based on the VHF signals for voice communications in aircrafts, and other advances in indoor cooperative localisation. Besides, an overview of the L&T chapter in IRACON's book was given and some examples of success stories and potential future joint activities were discussed.

Newcomers to the Action.

EuCAP2020 COST Session CA15104 (IRACON): Measurements and Simulations in Channel Modelling in Wireless Body Area Networks

Organisers: Luis M. Correia (IST, University of Lisbon), Sławomir J. Ambroziak (Gdańsk University of Technology)

Wireless Body Area Networks (WBANs) are playing an increasingly important role in the next generation of wireless systems, as they will allow for the integration of the various handheld and wearable devices into the surrounding environment and infrastructure. Thus, an important challenge is to increase the connection reliability of the in-, on- and off-body links, together with the body-to-body ones. In order to boost the overall system performance, a good and deep understanding of the radio channel in WBANs is required. This has to be made possible by studying the propagation channel via measurements and simulations, and developing models considering various scenarios (i.e., antenna type and placement, body type, movements and environments). This workshop was planned to give the possibility to exchange views on various methodologies of channel modelling, including simulation and measurements, and to discuss approaches to integrate results in order to build flexible channel models for WBANs. This workshop is congruent with the scope of the Disciplinary Working Group DWG1: "Radio Channels" and Sub Working Group SEWG-IoT: "Internet-of-Things for Health" of COST CA15104 Action (IRACON).

Due to the current tough situation in the Europe the EuCAP 2020 was cancelled. The papers that have been approved for IEEE Xplore publication in the review process are now available electronically.

Discussion topics:

Human Body Modelling for Wireless Body Area Network Optimisation.

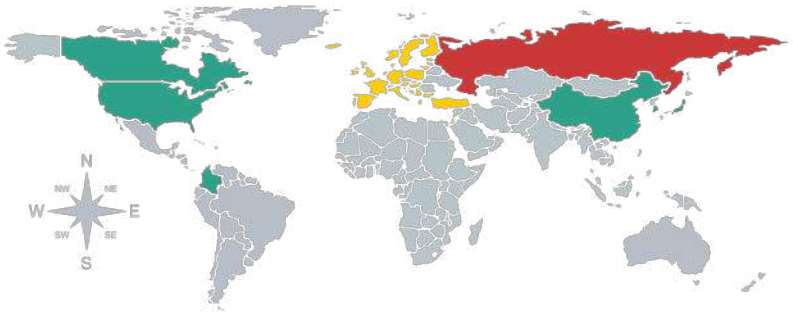
Preliminary Empirical Validation of a Polarised Off-Body Channel Model with Dynamic Users.

Real-Time Demonstration of Antenna Effects on Emulated Wireless Capsule Endoscope Links.

Human Posture Effects of WBAN Measurement in a Reverberation Chamber.

Experimental Parameter Optimisation for Adaptive LoRa Modulation in Body-Centric Applications.

Facts & Figures



Signatory countries: 35
Austria, Belgium, Bosnia and Herzegovina, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, fYR Macedonia, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Lithuania, Luxembourg, Malta, Montenegro, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom

COST international partner countries: 6
Canada, China, Columbia, Japan, South Korea, USA

COST Near Neighbour Countries: 1
Russian federation