

MOBILE COMMUNICATIONS GROUP (MCG) ANNUAL RESEARCH REPORT 2018/2019

The 2019 has been a successful year for the Mobile Communications Group. Apart from the important number of European projects reached, the quantity and quality of thesis defended, and the number of relevant publications, the organization of the EuCNC 2019 and the Global 5G Event has been the most important event that has put the MCG/ITEAM in the spotlight of the field of wireless communications. In the called Valencia 5G Week, the more relevant experts in 5G offered presentations and demonstrations of this technology. During the months of preparation of these demonstrations, the MCG worked together with important companies such as Orange, ZTE or RTVE and all this hard work is giving rise to new collaborations and future projects.

1.- PROJECT ACTIVITIES

5G-Xcast

5G-Xcast has developed broadcast and multicast Point to Multipoint (PTM) capabilities for 5G New Radio (NR) and the Core Network as built-in features integrated in the overall 5G system architecture considering Media & Entertainment (M&E), Automotive (Auto), Internet of Things (IoT) and Public Warning (PW) use cases. 5G-Xcast has also designed a dynamically adaptable network architecture with layer independent network interfaces to dynamically and seamlessly switch between unicast, multicast and broadcast modes, or use them in parallel. The results of the project are the starting point for the definition of 5G multicast/broadcast in Release-17.

The project has been coordinated by Prof. David Gomez-Barquero, member of the iTEAM. The project has 8 M€ budget, and 19 partners from 9 countries, including Nokia, Telecom Italia, British Telecom, BBC and the EBU. iTEAM has also led the definition of the 5G-Xcast air interface.

5G-CARMEN

This project, funded by the European Commission, has progressed with relevant impact on research community, being declared the most active project on autonomous driving by the European Commission.

The “Munich-Bologna corridor”, which covers 600 km of roads across three countries (Italy, Austria and Germany), is one of the most important corridors identified by the European Union for an initiative to improve the mobility of people and goods throughout Europe. As part of the 5G-CARMEN project, 5G technologies will be deployed along selected stretches of the motorway in the border regions.

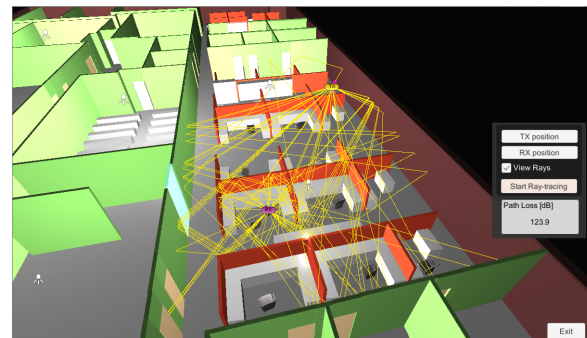


Figure 1: Channel Modelling Tool based on Ray Tracing Techniques

5G-SMART

5G-SMART unlocks the value of 5G for smart manufacturing through demonstrating, validating and evaluating its potential in real manufacturing environments. 5G-SMART trials will test the most advanced 5G integrated manufacturing applications such as digital twin, industrial robotics and machine vision based remote operations. 5G-SMART will undertake the first ever evaluation of ElectroMagnetic Compatibility (EMC), channel measurements and co-existence between public and private industrial networks in real manufacturing environments easing the integration of 5G. The new 5G features, developed in 5G-SMART such as time synchronisation and positioning for manufacturing use cases represent a technological leap.

5G-SMART lead by Ericsson brings together a strong consortium of partners involved in every aspect of the manufacturing ecosystem. Prof. Jose F. Monserrat, member of the iTEAM, is the Innovation Manager of the Project. This project is funded by the European Commission.

5G-TOURS

The goal of 5G-TOURS is to get the European 5G Vision of “5G empowering vertical industries” closer to commercial deployment with highly innovative use cases involving cross-industry partnerships, and to demonstrate the ability of 5G to support multiple vertical use cases concurrently on the same infrastructure. 5G-TOURS vision is to improve the life in the city for the citizens and tourists, making cities more attractive to visit,

more efficient in terms of mobility and safer for everybody. 5G-TOURS builds on three themes: the touristic city (Turin), the mobility efficient city (Athens), and the safe city (Rennes). iTEAM is involved in the touristic city, where visitors of museums and outdoor attractions are provided with 5G-based applications to enhance their experience while visiting the city. This includes VR/AR applications to complement the physical visit with additional content, involving interactive tactile communications. The experience of the visitors is also enhanced with robot-assisted services, telepresence to allow for remote visits, as well as live events enabled by mobile communications such as multi-party concerts.

5G-TOURS has almost 15M€ budget and a consortium of 27 partners. The project is led by Ericsson Italy. UPV is the leader of the broadcast use case, and will be involved in all the media distribution and production trials in Turin.

VLC-CAMPUS-5G

VLC-CAMPUS-5G is the project to launch a 5G technology wireless communications platform on the campus of the Polytechnic University of Valencia, which will support the testing of new 5G equipment, applications and services and will promote Valencia as a 5G city. The VLC-CAMPUS-5G project is aligned with the evolution of mobile networks towards 5G, which will bring important developments and improvements not only in terms of capacity, latency, connection density, quality and user experience, but also in terms of flexibility, efficiency, scalability and openness of the networks, which will allow to offer new services.

The deployment of the VLC-CAMPUS-5G test-bed is based on the expansion of the current communications' infrastructures of the UPV, by the acquisition of the necessary equipment for the emission and experimental tests of 5th generation mobile services. The objective is to cover all the use cases that occur in a closed and controlled environment such as the campus of the UPV, in which more than 50 thousand people move daily. The VLC-CAMPUS-5G project is an initiative that covers the entire University, being endorsed and supported by research groups from different Institutes and Departments, and with the particular support of the Infrastructure Service and the Calculation Center.

Millimetre Wave Communications in Built Environments (WaveComBE)

WaveComBE (www.wavecombe.eu) is an Industrial and Training Network dealing with the ultra-dense deployment of millimetre-wave (mmW) small-cells (SCs) in conjunction with massive multiple-input multiple output (MIMO) in 5G and beyond 5G (B5G) wireless networks. In WaveComBE the MCG is developing the simulation tools to analyse the human body blocking to millimetre wavelength radio frequencies, as well as efficient planning tools to deploy future access points in bands

around and above 30GHz, as well as researching on beamforming techniques for the physical layer of mm-wave mobile communications. Two people are hired by the UPV in the framework of the project. Currently, both are enjoying their secondments in other beneficiary's facilities, one in UK and the other in Sweden. During the second year of the project, they have published two papers in international conferences and have attended the training events organized by the consortium. Narcís Cardona is the project coordinator and it is funded by the European Commission under the Marie Skłodowska-Curie programme.

Wireless In-Body Environment Communications (WIBEC)

This project is an Innovative Training Network that aims to train excellent researchers in the field of wireless communications inside the body. In particular, the two main application areas are Wireless Capsule Endoscopy (WCE) and pacemakers. WIBEC project will have a duration of 4 years during which 16 researchers will be trained in 8 European institutions, among them. WIBEC consortium is coordinated by Oslo University Hospital from Norway and is composed of 3 universities (Norges Teknisk-Naturvitenskapelige Universitet, Norway; Universitat Politècnica de València, Spain; and Technische Universität Dresden, Germany); 3 companies (Sorin CRM, France; Ovesco AG, Germany; and ValoTec, France); and 2 university hospitals (Hospital Universitario y Politécnico La Fe, Spain; and Oslo University Hospital, Norway). This project has been funded by the European Commission

ElectroMagnetic prObE for early Tumour dEtection (EMOTE)

This is a joint collaborative project with Hospital La Fe, jointly funded by both public institutions. This project is devoted to the measurement of the dielectric properties of in vivo healthy and malignant colon tissues by using animal models (rats). In this way, it would be possible to evaluate whether the differences previously found for humans are also repeated at in in-vivo conditions. Furthermore, these tests will be used to verify and refine the methodology for the diagnosis of malignant body tissues based on the dielectric properties of both kind of tissues. This project has been funded by the Hospital Universitario y Politécnico La Fe and the Universitat Politècnica de València.

Sonda Colorrectal para la Detección Electromagnética de Tumores (COLODEM)

COLODEM project is based on the development of a tool for colorectal cancer detection based on the reported difference in the electromagnetic properties of healthy and malignant colon tissues. Such tool will consist of three main parts: flexible probe to be integrated in the colonoscope, a software algorithm for measuring and identifying the malignant tissues, and a laboratory platform for testing. This platform will be based on the

electromagnetic reproduction of a human colon with presence of malignant tissues and it will be used for both the development of the probe and the detection algorithm as well as the training of the physicians. In this manner, the time needed for developing the tool will be dramatically shortened since it will be no need of animal testing. This project has been funded by the Universitat Politècnica de València.

2.- FEATURED PUBLICATIONS

Jordi Joan Gimenez, Jose Luis Carcel, Manuel Fuentes, Eduardo Garro, Simon Elliott, David Vargas, Christian Menzel, David Gomez-Barquero:

5G New Radio for Terrestrial Broadcast: A Forward-Looking Approach for NR-MBMS. IEEE Transactions on Broadcasting 65(2): 356-368 (2019) DOI: 10.1109/TBC.2019.2912117

3GPP LTE eMBMS release (Rel-) 14, also referred to as further evolved multimedia broadcast multicast service (FeMBMS) or enhanced TV (EnTV), is the first mobile broadband technology standard to incorporate a transmission mode designed to deliver terrestrial broadcast services from conventional high power high tower (HPHT) broadcast infrastructure. With respect to the physical layer, the main improvements in FeMBMS are the support of larger inter-site distance for single frequency networks (SFNs) and the ability to allocate 100% of a carrier's resources to the broadcast payload, with self-contained signaling in the downlink. From the system architecture perspective, a receive-only mode enables free-to-air (FTA) reception with no need for an uplink or SIM card, thus receiving content without user equipment registration with a network. These functionalities are only available in the LTE advanced pro specifications as 5G new radio (NR), standardized in 3GPP from Rel-15, has so far focused entirely on unicast. This paper outlines a physical layer design for NR-MBMS, a system derived, with minor modifications, from the 5G-NR specifications, and suitable for the transmission of linear TV and radio services in either single-cell or SFN operation. This paper evaluates the NR-MBMS proposition and compares it to LTE-based FeMBMS in terms of flexibility, performance, capacity, and coverage.

M. Barbi, C. Garcia-Pardo, A. Nevárez, V. Pons Beltrán and N. Cardona, "UWB RSS-Based Localization for Capsule Endoscopy Using a Multilayer Phantom and In Vivo Measurements" in IEEE Transactions on Antennas and Propagation, vol. 67, no. 8, pp. 5035-5043, Aug. 2019. doi: 10.1109/TAP.2019.2916629

Abstract: In recent years, the localization for capsule endoscopy applications using ultrawideband (UWB) technology has become an attractive field of investigation due to its potential benefits for patients. The literature concerning performance analysis of radio frequency-based localization techniques for in-body applications at UWB frequencies is very limited. Available studies mainly

rely on finite-difference time-domain simulations, using digital human models and on experimental measurements by means of homogeneous phantoms. Nevertheless, no realistic analysis based on multilayer phantom measurements or through in vivo experiment has been reported yet. This paper investigates the performance of the received signal strength-based approach for 2-D and 3-D localizations in the UWB frequency band. For 2-D localization, experimental laboratory measurements using a two-layer phantom-based setup have been conducted. For 3-D localization, data from a recently conducted in vivo experiment have been used. Localization accuracy using path loss models, under ideal and non-ideal channel estimation assumptions, is compared. Results show that, under nonideal channel assumption, the relative localization error slightly increases for the 2-D case but not for the in vivo 3-D case. Impact of receivers selection on the localization accuracy has also been investigated for both 2-D and 3-D cases.

A. Fornes-Leal et al., "Dielectric Characterization of In Vivo Abdominal and Thoracic Tissues in the 0.5-26.5 GHz Frequency Band for Wireless Body Area Networks" in IEEE Access, vol. 7, pp. 31854-31864, 2019. doi: 10.1109/ACCESS.2019.2903481

Abstract: The dielectric properties of biological tissues are of utmost importance in the development of wireless body area networks (WBANs), especially for implanted devices. The early design stages of medical devices like capsule endoscopy, pacemakers, or physiological sensors rely on precise knowledge of the dielectric properties of the tissues present in their surrounding medium. Many of these applications make use of electromagnetic phantoms, which are software or physical models that imitate the shape and the electromagnetic properties of the tissues. They are used for designing devices in software simulations and for testing them in laboratory trials, aiding in both the development of WBAN antennas or in communication link evaluations. The existing reports about dielectric in vivo properties are limited and have drawbacks like: low variety of characterized tissues, lacking some relevant ones, and limitations and inhomogeneity in the measured frequency range. This paper aims at filling that gap by providing a new database of dielectric properties of biological tissues measured in vivo. In particular, it is focused on the tissues of the thoracic and the abdominal regions, measured at the same wide frequency band, on the same animal specimen, and under the same conditions. The properties have been obtained by measuring porcine tissues in the 0.5-26.5 GHz band with the open-ended coaxial technique. In this paper, we focus on those tissues that have been scarcely characterized so far in the literature, like heart, esophagus, stomach, and pancreas. The Cole-Cole fitting parameters of the measured tissues and their uncertainties are provided.

S. Perez-Simbor, C. Andreu, C. Garcia-Pardo, M. Frasson and N. Cardona, "UWB Path Loss Models for Ingestible Devices" in IEEE Transactions on Antennas and Propagation, vol. 67, no. 8, pp. 5025-5034, Aug. 2019. doi: 10.1109/TAP.2019.2891717

Abstract: Currently, medical devices such as the wireless capsule endoscopy (WCE) are used for data transmission from inside to outside the body. However, for certain applications such as WCE, the data rates offered by the current medical frequency bands can be insufficient. Ultrawideband (UWB) frequency band has become an interesting solution for this. However, to date, there is no formal channel path loss (PL) model for the UWB frequency band in the gastrointestinal (GI) scenario due to the huge differences between the proposed studies. There are three main methodologies to characterize the propagation channel, software simulations, and experimental measurements either in phantom or in in vivo animals. Previous works do not compare all the methodologies or present some disagreements with the literature. In this paper, a dedicated study of the PL using the three aforementioned methodologies (simulations, phantoms, and in vivo measurements) and a comparison with previous studies in the literature is performed. Moreover, numerical values for a PL model which agrees with the three methodologies and the literature are proposed. This paper aims at being the starting point for a formal PL model in the UWB frequency band for wireless body area networks in the GI scenario.

S. Castelló-Palacios, C. Garcia-Pardo, M. Alloza-Pascual, A. Fornes-Leal, N. Cardona and A. Vallés-Lluch, "Gel Phantoms for Body Microwave Propagation in the (2 to 26.5) GHz Frequency Band" in IEEE Transactions on Antennas and Propagation, vol. 67, no. 10, pp. 6564-6573, Oct. 2019. doi: 10.1109/TAP.2019.2920293

Abstract: Tissue phantoms are widely used for assessing the interaction between the electromagnetic waves and the human body. These are especially key in body area networks, where the body itself acts as the propagation medium since transmission is highly influenced by its diverse dielectric properties. Gels are suitable materials because of their high water content, which is required to mimic the dielectric properties of most tissues. In this paper, PHEA gels are suggested for achieving those properties due to their synthetic nature, which gives them the possibility to be swollen reversibly in more types of mixtures, in addition to water. These gels can be tailored to control the amount of liquid they embed so that they can imitate different body tissues in a wide bandwidth (2-26.5 GHz), which includes most of the current mobile communication and medical bands. This versatility offers the chance to create heterogeneous models of particular regions of the body, and thus improve the test realism. In addition, they own better mechanical and stability properties than the widely used agar or gelatin.

Muhammad Faheem Awan, Sofia Perez-Simbor, Concepcion Garcia-Pardo, Kimmo Kansanen and Narcis Cardona, "Experimental Phantom-Based Security Analysis for Next-Generation Leadless Cardiac Pacemakers", in Sensors 2018, 18(12), 4327. doi: 10.3390/s18124327

Abstract: With technological advancement, implanted medical devices can treat a wide range of chronic diseases such as cardiac arrhythmia, deafness, diabetes, etc. Cardiac pacemakers are used to maintain normal heart rhythms. The next generation of these pacemakers is expected to be completely wireless, providing new security threats. Thus, it is critical to secure pacemaker transmissions between legitimate nodes from a third party or an eavesdropper. This work estimates the eavesdropping risk and explores the potential of securing transmissions between leadless capsules inside the heart and the subcutaneous implant under the skin against external eavesdroppers by using physical-layer security methods. In this work, we perform phantom experiments to replicate the dielectric properties of the human heart, blood, and fat for channel modeling between in-body-to-in-body devices and from in-body-to-off-body scenario. These scenarios reflect the channel between legitimate nodes and that between a legitimate node and an eavesdropper. In our case, a legitimate node is a leadless cardiac pacemaker implanted in the right ventricle of a human heart transmitting to a legitimate receiver, which is a subcutaneous implant beneath the collar bone under the skin. In addition, a third party outside the body is trying to eavesdrop the communication. The measurements are performed for ultrawide band (UWB) and industrial, scientific, and medical (ISM) frequency bands. By using these channel models, we analyzed the risk of using the concept of outage probability and determine the eavesdropping range in the case of using UWB and ISM frequency bands. Furthermore, the probability of positive secrecy capacity is also determined, along with outage probability of a secrecy rate, which are the fundamental parameters in depicting the physical-layer security methods. Here, we show that path loss follows a log-normal distribution. In addition, for the ISM frequency band, the probability of successful eavesdropping for a data rate of 600 kbps (Electromyogram (EMG)) is about 97.68% at an eavesdropper distance of 1.3 m and approaches 28.13% at an eavesdropper distance of 4.2 m, whereas for UWB frequency band the eavesdropping risk approaches 0.2847% at an eavesdropper distance of 0.22 m. Furthermore, the probability of positive secrecy capacity is about 44.88% at eavesdropper distance of 0.12 m and approaches approximately 97% at an eavesdropper distance of 0.4 m for ISM frequency band, whereas for UWB, the same statistics are 96.84% at 0.12 m and 100% at 0.4 m. Moreover, the outage probability of secrecy capacity is also determined by using a fixed secrecy rate.

3.- AWARDS

5G-CARMEN got the recognition as best booth in the EuCNC event organized by the European Commission in Valencia in June 2019.

4.- EUCNC AND G5GE

Last June from 17th to 21th, the Mobile Communications Group organized two of the most important events in the field of Communications: the European Conference on Networks and Communications (EuCNC 2019) and the Global 5G Event. Both events were held in the Valencia Conference Centre, that gathered more than 800 international experts from both the scientific community and the world's leading telecommunications companies, to address the present and future of mobile telecommunications and the 5G technology industry. During that week, there were different demonstrations of practical applications and use cases of 5G technology, including the first global holographic videoconference 5G SA, a remote car driving

system, an industrial robot controlled with 5G and an immersive reality cave. The world's first live transmission was also carried out using a directly connected HD camera, thanks to the collaboration of RTVE and the UPV. All this was possible thanks to the independent technology 5G SA developed by the multinationals ZTE and Orange. All these applications were evaluated during the weeks prior to the event at the Universitat Politècnica de València, in the framework of the VLC-5G project. In these tests, in addition to the institute iTEAM also participated the Institute ai2 (in cases of automobiles and remotely controlled robots) and the Institute I3B, which collaborated in the development of the cave of immersive reality. There was also a demonstration of rapid deployment of 5G emergencies in La Marina de València: A helicopter, drones and ambulances connected to its network and coordinated with each other, allowed a rapid response to the simulated emergency situation.



Figure 2: Local Organizing Committee



Figure 3: Robotic arm demonstration



Figure 4: General view of the Valencia Conference Centre