The Newsletter of the

Department of Electronics Engineering

TOR VERGATA
UNIVERSITY OF ROME

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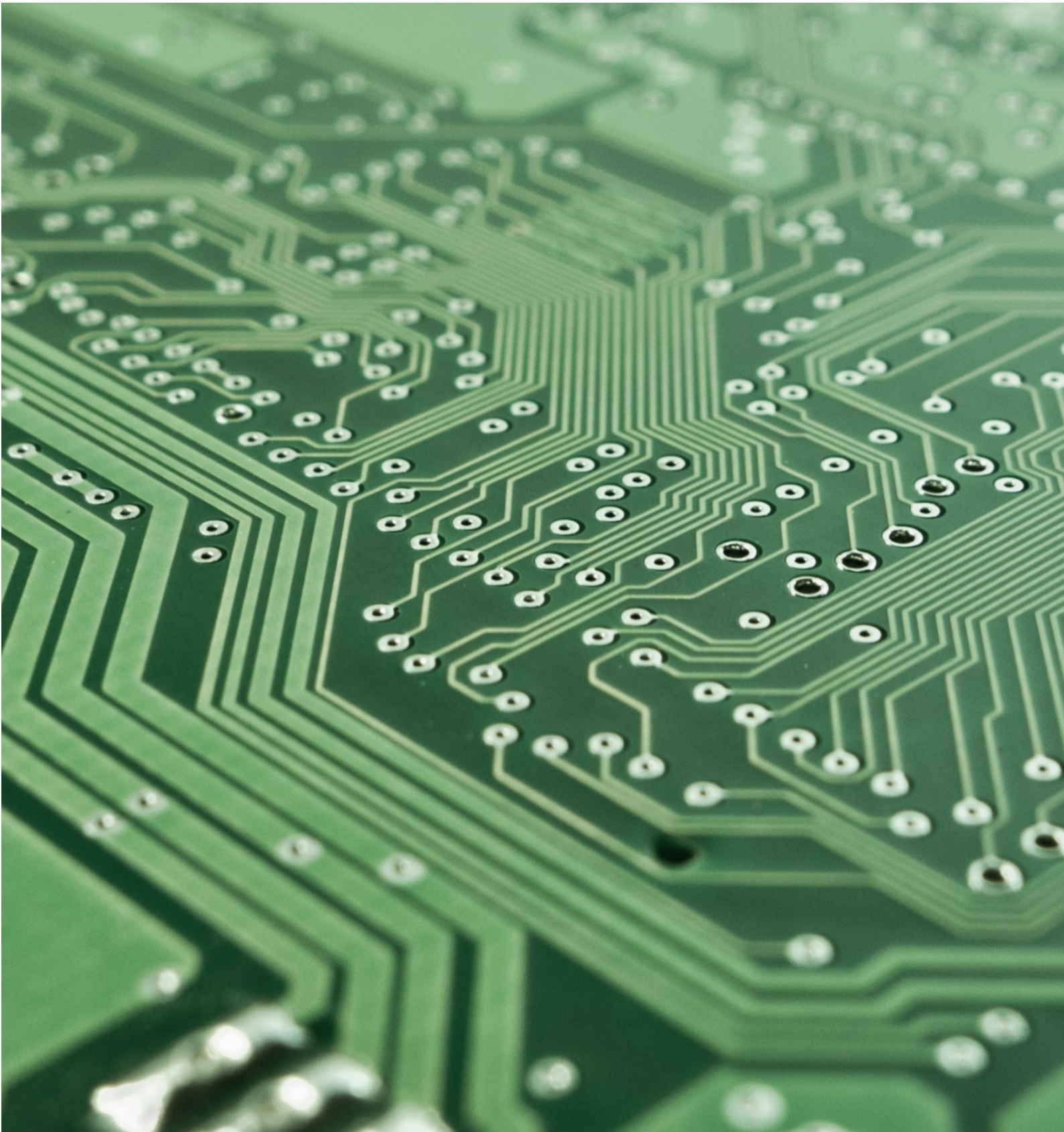

The University of Rome "Tor Vergata" (www.uniroma2.it) was founded in 1982 and it is now one of the most important Italian universities. Placed in a 600-hectare campus, it offers to its 40,000 students more than 100 courses of Bachelors Degree and Masters Degree, many Masters, PhD Courses and Schools of Specialization.
The Department of Electronics Engineering was born in 1983 and its success is the result of the hard work of its Teachers, Researchers, employees and PhD students for a total number of 150 people. As for the traditional scientific sectors, the expertise of the Department goes from Electronics, Optoelectronic, Electrotechnics to Measures and Telecommunications. The Department is involved in the following research domains: Environment, Energy, Industry, Internet, Multimedia, Health, Security, Space. The high quality of the Research is proved by the international publications (about 100 per year), by the number of European and national research projects (about 40 projects in the last five years for an amount of 15 million euros) and by the ten spin-offs born inside the Department. As for the didactic offer, the Department holds three Bachelors Degree, three Masters Degree (two of them completely taught in English), six Masters and a PhD School. To increase its quality, the Department has a didactic Laboratory of Electronics with 21 work tables, 14 of them fully equipped with digital oscilloscope, logic state analyzer, signal generator, digital multimeter, and a Computer Science Laboratory of the School of Engineering, with 40 fully equipped working stations.
The Newsletter of the Department of Electronics Engineering, is published twice a year. This newsletter is conceived as a means to share information about the Department with students, faculty, staff, alums and researchers in Italy and around the world.

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Message from the Director

Welcome to the first issue of the Newsletter of the Department of Electronics Engineering, "Tor Vergata" University of Rome. The aim is indeed to provide our stakeholders (e.g. students, companies, colleagues) with an up-to date picture of the Department and its scientific achievements, as well as an insight into educational activities. As you may notice, the structure of the Newsletter, that will be maintained in future issues, is composed by a keynote address from recognized experts and friends of the Department (Alfonso Farina and Mario Frasca in the present issue), followed by spotlight research samples. The latter ones, simply identifying current research streams of the Department, represent just a synthetic description, useful for the reader to identify the relevant researchers to probe further in case of interest. In this issue, a few examples have been given, and future issues will help in providing a more complete picture of the ongoing activities. The Newsletter is completed by a spotlight on important and new didactic initiatives: in the present issue the Mechatronics Engineering Degree is focused, being the most recent effort in which the Department invested its resources. An upcoming events Section, listing events directly organized or with major contributions by members of the Department, together with an Achievements section completes the picture. I hope that this Newsletter may become a useful tool for our colleagues and all those interested in collaborating with us. Enjoy Reading!

Ernesto Limiti, Director of the Electronics Engineering Department

Keynote Address

J. B. Fourier: The Endless Relevance of his Scientific Findings After 250 Years From his Birth

Last year recurred 250th anniversary of the birth of Jean Baptiste Joseph Fourier. Joseph Fourier gave great and deep contributions both to physics and mathematics and most of our everyday technology is built on his formulation of the trigonometric series and transform, named after him. Joseph Fourier was born on March 21, 1768 at Auxerre in France, son of a tailor. He remained orphan at age of 9 so, he was educated by the Benedictine order at the convent of St. Mark. He was involved in the French Revolution and, imprisoned during the Terror, risked his life. Napoleon Bonaparte took him, as scientific advisor, on his campaign in Egypt. His fundamental work was the book Théorie Analytique de la Chaleur (The Analytical Theory of Heat), published on 1822, where he laid down the foundations of the trigonometric series and postulated his most famous equation describing the heat diffusion. In the effort to solve the heat equation, that lies at the foundations of the stochastic processes, Fourier came out with his series. This work was mostly opposed by Laplace and Lagrange and the name of "false" theorem was attached to the Fourier series, the main reason being the unclear conditions of its convergence. This problem was finally addressed by Dirichlet in 1829, just a year before Fourier's death.

Today, Fourier's legacy is more alive than ever. The Fourier series has found vast application in a innumerable quantity of fields and several other applications keep on appearing. Similarly, the heat equation, with its kernel, is routinely applied in several proofs of theorems and gets its natural generalization on manifolds with the Ricci flow used in the Perelman's proof of the Poincaré conjecture (see Perelman Grisha, "Ricci flow with surgery on three-manifolds", in arxiv:math.DG/0303109, 2003). Being it at the foundations of the stochastic processes, this establishes a natural link between geometry and random processes on a generic manifold. In particle physics, Fourier series represents the main tool to perform calculations of cross sections and decay times that are so exceptionally well verified at the Large Hadron Collider (LHC) at Conseil Européen pour la Recherche Nucléaire (CERN). Graph theory also benefits from Fourier series, see S. Sardellitti, S. Barbarossa and P. D. Lorenzo, "On the Graph Fourier Transform for Directed Graphs", in IEEE Journal of Selected Topics in Signal Processing, vol. 11, no. 6, pp. 796-811, September 2017, where signal processing is performed generalizing the concept of Fourier transform on graphs.

For technology, it is essential to have algorithms to evaluate the Fourier transform as fast as possible. So, it came as a breakthrough the proposal by Cooley and Tuckey of the fast Fourier Transform (FFT) on 1965. This made possible real-time applications. Today, further improvements on the original Cooley and Tuckey's algorithm are underway at MIT with the sparse FFT working efficiently on large dataset. E.g., this could yield efficient algorithms for Synthetic Aperture Radar (SAR) applications. For a history of FFT, a fine article is: M. Heideman et al. "Gauss and the history of the fast fourier transform", IEEE ASSP Magazine, Volume: 1, Issue: 4, October 1984.

The heat equation has a strong formal resemblance with the Schrödinger equation that is a basic tool in quantum mechanics. Recently, this relationship was deepened by a formulation of a new class of stochastic processes making this link deeply rooted in the non-commutative geometry as formulated by Alain Connes, making also possible a clearer understanding of the fabric of the space-time (see M. Frasca, A. Farina, "Numerical proof of existence of fractional powers of Wiener processes", Springer Signal, Image and Video Processing, Volume 11, Issue 7, October 2017, and M. Frasca "Noncommutative Geometry and Stochastic

Processes", International Conference on Geometric Science of Information 2017, together with M. Frasca, A. Farina, "Parcels of Universe or why Schrödinger and Fourier are so relatives?", in arXiv:1804.05204, 2018). To have an idea of the vitality of Fourier's achievements, a recent commemorative book has been published: Frédéric Barbaresco and Jean-Pierre Gazeau (Eds.), Joseph Fourier 250th Birthday - Modern Fourier Analysis and Fourier Heat Equation in Information Sciences for the XXIst century, MDPI (March 2019). Fourier, in a pair of memories, is also credited with the discovery of the greenhouse effect that is so relevant nowadays (see "Remarques Générales Sur Les Températures Du Globe Terrestre Et Des Espaces Planétaires". Annales de Chimie et de Physique. 27: 13667 (1824) and "Mémoire Sur Les Températures Du Globe Terrestre Et Des Espaces Planétaires", Mémoires de l'Académie Royale des Sciences, 7: 569604, 1827). Several good media have been also produced for educational aims about the Fourier series. An example is given through a video available on YouTube ("Epicycles, complex Fourier series and Homer Simpson's orbit") where the question of epicycles is readily understood as a trigonometric series reproducing Homer Simpson silhouette.

It is plausible to expect a lot of other applications for Fourier's discoveries in the near future, to testify the huge value and the enormous impact they have had for all humankind.

Alfonso Farina, Chair of IEEE AESS Italy Section Chapter.
Marco Frasca, MBDA Italia S.p.A.

Research Spotlights

Uncovering the Role of Alloy Fluctuations on Nitride LED Performance

Statistical fluctuations of the local indium concentration in InGaN alloys play an important role for the electronic and optical properties of nitride-based light emitting diodes (LEDs), which is currently the most important technology for solid state lighting. Spatial fluctuations on the nanometer scale in the atomic composition of InGaN has been found independently by different research groups to affect the localization of charge carriers in the system, and thus to influence in particular device efficiency. Experimentally it is found, that the longer the wavelength of InGaN LEDs, i.e. going from blue to green and amber, the lower the efficiency. This is known as the "green gap", and is related to the fact that longer wavelength emission from an InGaN LED requires a higher indium content. This leads to technological difficulties due to the large lattice mismatch between the alloy constituents InN and GaN, but also to larger effects due to alloy fluctuations. Our group has been studying this topic since several years, finding for example a correlation between random alloy fluctuations and the efficiency drop towards longer wavelength. Based on structural characterization, is it commonly believed that InGaN is forming what is known as a random alloy, meaning that there is no spatial correlation in the distribution of the indium atoms. We recently found, however, that even small deviations from such a uniform alloy, which might not be observable experimentally, lead to important changes in the optoelectronic properties. For this, we performed detailed simulations on realistic LED structures, using an atomistic quantum-mechanical model to describe the electronic states and the optical properties in the light-emitting quantum well (see Figure 1). In such a model, each atom is considered explicitly, which allows to simulate a realistic statistically disordered alloy with up to several hundred thousand atoms. Since the model describes a small portion of the actual LED, the macroscopic properties like the emission spectrum is obtained by summing the result of many different random structures. Our results show, that increasing non-uniformity in the alloy leads to a strong scattering in the energy of the emitted photons, which results in a broadening of the LED emission spectrum. Indeed, models that cannot capture the details of the atomic structure always predict a much narrower spectrum than what is measured experimentally. On the other hand, also the strengths of the optical transitions shows large statistical spread, which influences the efficiency of the LED. Figure 1 shows the calculated emission spectra for different degrees of alloy non-uniformity (100% uniform corresponding to an ideal random alloy with no spatial correlation), in comparison with the spectrum measured for an LED with similar indium content. Allowing for some degree of non-uniformity can be seen to provide better agreement between theoretical prediction and measurement.

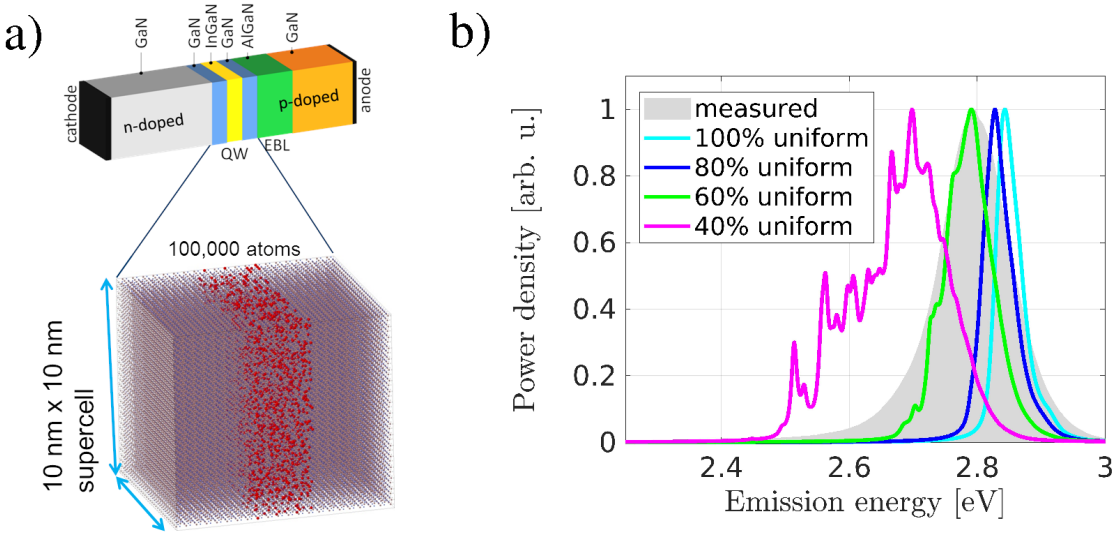

Figure 1: (a) Schematic figure of the simulated p-i-n single quantum well LED. Only the quantum well including small portions of the GaN barriers is model atomistically. The randomly distributed indium atoms are shown in red. (b) the calculated emission spectra for different degrees of non-uniformity, in comparison with a measured spectrum (gray shaded area).

Researchers: Alessia Di Vito, Matthias Auf der Maur, Aldo Di Carlo, Alessandro Pecchia (ISMN CNR).

Analysis and Design of Smart Gateway Configurations at Q/V Band

The next generation of High Throughput Satellite (HTS) systems for broadband distributed user access targets the Tbit/s connectivity. The latter can be achieved overcoming the spectrum limitations of current Ka-band (20-30 GHz) based systems, in particular introducing the use of Q/V-band (40-50 GHz) and W-band (70-90 GHz), where a large uncrowded spectrum portion is allocated for satellite communication services. As a matter of fact, the forthcoming innovative HTS architectures are based on the use of Q/V-band feeder links and Ka-band user links. In this framework, a European experimental campaign for the optimization of Q/V-band satellite communication, funded by the Italian Space Agency and the European Space Agency, is currently undertaken. It is well known that satellite communication links at EHF bands potentially suffer from high levels of rain attenuation. Feeder-link macro site diversity is one of the most promising propagation impairments mitigation techniques (PIMTs) that can be used with the aim to limit the system outage probability at the usual system requirements (0.3% or less). Smart Gateway (SG) spatial diversity schemes for the feeder link are based on the use of a pool of gateways (GWs). The GWs of a pool are connected with each other through a terrestrial fiber network and managed by a network controller so that feeder link data traffic can be routed to counteract deep fades on one (or more) GW(s). In this activity, we propose an analytical formulation to calculate the outage probability of an EHF satellite communication system that implements a macro site diversity scheme to mitigate propagation impairments. The model can be used in the system design phase to calculate the diversity gain and optimize the system dimensioning.

Website: http://eln.uniroma2.it
Researchers: Tommaso Rossi, Mauro De Sanctis, Fabio Maggio, Marina Ruggieri.

Radar Calibration and Cross Section Measurements

The classical radar calibration by measuring the various terms which made up the radar equation (i.e. antenna gain, transmitted power, losses, etc.) is lengthy and complicated, not suited to some practical applications in the field. In this research, aimed to the creation of quantitative X-band clutter maps with special attention of suburban areas, a more cost/effective approach is investigated. It is based upon defining the relationship (linear above the noise plafond and below the receiver saturation) between the Radar Cross Section (RCS) of known, standard objects (corner reflectors, metallic spheres) installed in clutter-free zones and the radar received power. A pertaining bonus of the proposed technique is the estimation, in a black-box way, of the global loss due to antenna, rotary joint, cable, amplifier, filters, up to the video stage. Live results have been obtained in the "Tor Vergata" area; they have been obtained using commercial X-band radar sets and a suited signal processing.

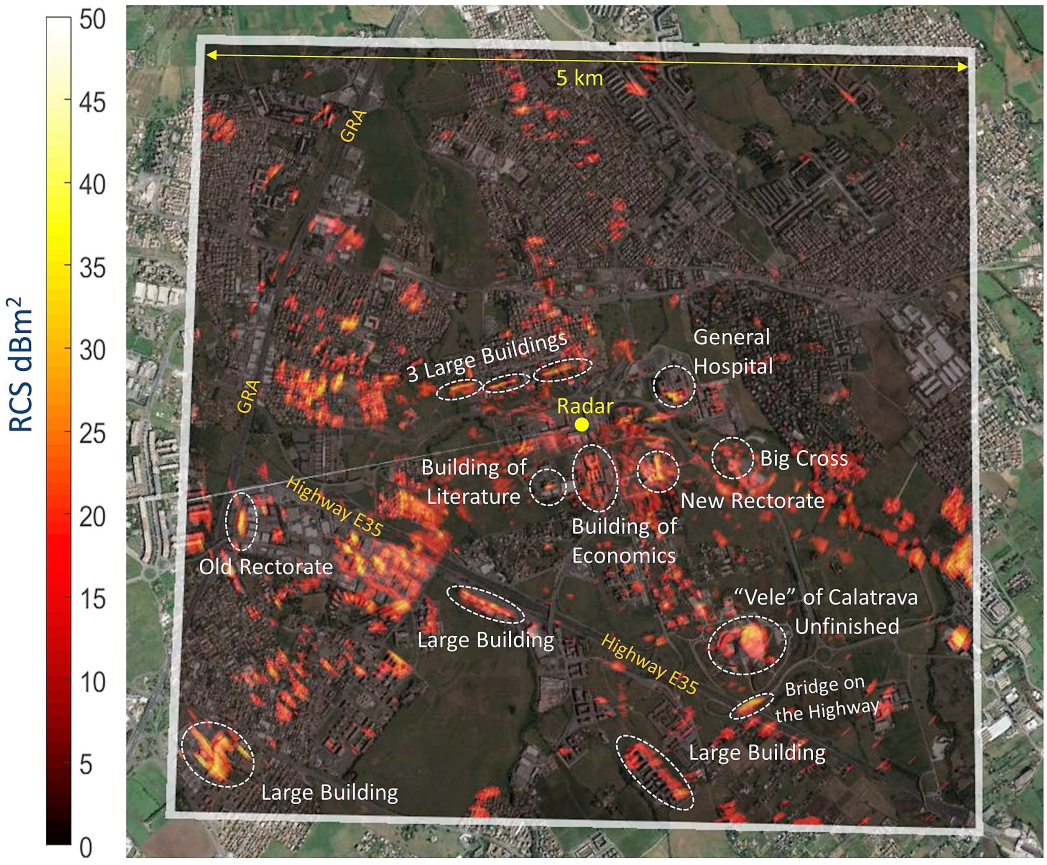

Figure 2: RCS clutter map overlaying on the Google Earth map.

Website: http://radarlab.uniroma2.it/wordpress/
Researchers: Gabriele Pavan, Gaspare Galati.

Secondary Surveillance Radar signals Degarbling and Jamming Mitigation by the use of Blind Source Separation

Secondary Surveillance Radar (SSR) Mode S signals are fundamental for the Future Air Traffic System. These signals, in addition to the traditional Radar Application, are used for the Traffic Alert and Collision Avoidance System (TCAS), Automatic Dependent Surveillance-Broadcast (ADS-B) System, and Traffic Information Service Broadcast (TIS-B) System. All the listed applications use the SSR- Mode S protocol called "1090 Extended Squitter (1090ES)" that was introduced about two decades ago and, today, it is affected by some important disadvantages. Firstly, the throughput of the channel is limited by the Garbling effect; i.e. the reception of superimposed messages due to the high number of transmitting aircraft in a dense scenario. Secondly, the 1090 MHz RF channel can be prone to jamming, that is the transmission of high power signals superimposing the aircraft messages. In this research, a method to mitigate these two effects using a multichannel receiver and a Blind Source Separation (BSS) technique is proposed.

Considering an m elements antenna connected to a multichannel receiver and a set of n different sources, the 'mixed' received signals is a linear combination of the individual source signals. The source signals can be unmixed (in the receiver) using an algebraic manipulation and a BSS technique to 'recover' an approximation of the original signals, through the determination of an 'unmixing' matrix without any knowledge about the antenna steering vector and the location of the sources. The proposed method (based on the Principal Component Analysis as BSS method) was evaluated using real signals received with an ADS-B receiver, both in jamming and garbling case. In Figure 3, an example, in case of real garbled signals, is reported. In the upper part of the Figure the four mixed signals, coming from the four elements antenna, are reported. Below, the four unmixed components, after the processing, are shown. In this example, three different sources (a Long Mode S reply, a Short Mode S reply and a DME signal composed of two couples of pulses) were found in the original garbled signals. In general, high jamming rejection was obtained for any tested jammer and, in the worst case, the decoded messages without errors increase from zero to more than the 60%. Finally, also the degarbling performances were improved and the number of garbled messages decoded without errors is about quadrupled after the proposed un-mixing process.

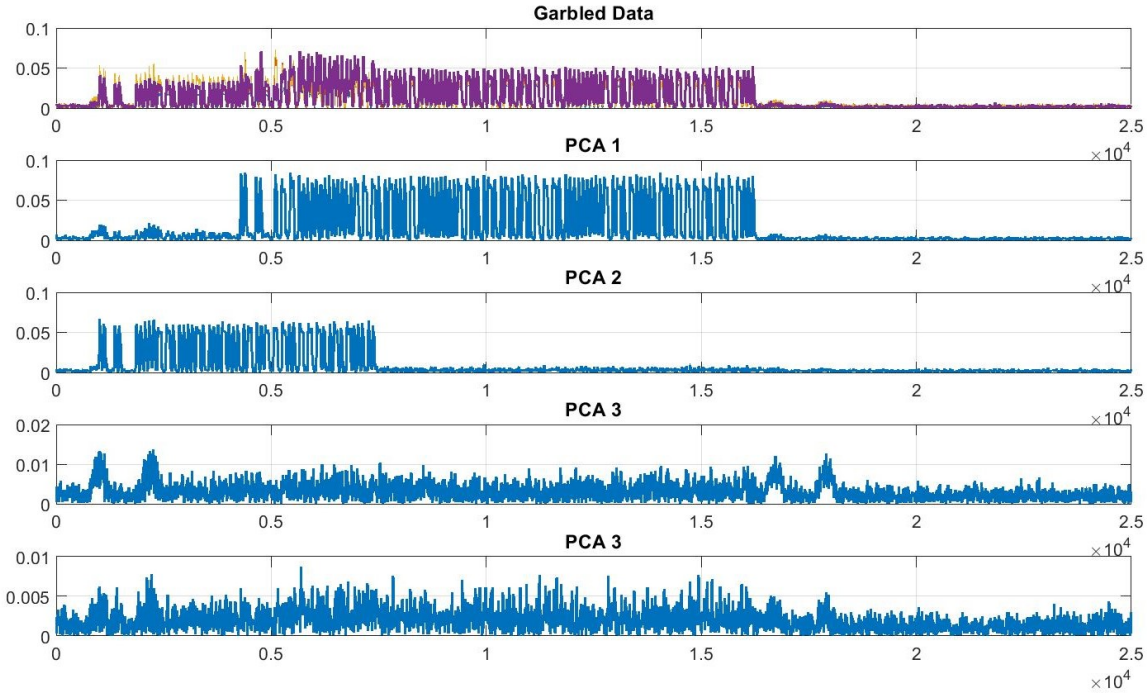

Figure 3: Example of De-garbled Signals.

Website: http://radarlab.uniroma2.it/wordpress/
Researchers: Mauro Leonardi, Emilio Piracci.

Rewritable Ghost Floating Gates by Tunneling Triboelectrification for Two-Dimensional Electronics

Everybody has personally experienced the triboelectric effect. For instance, by rubbing a plastic object on wool, electric charges can be stored on the plastic and can electrostatically attract objects with charges of the opposite type (e.g. a small piece of paper). Though the triboelectric effect was already observed around 600 BC by Thales of Miletus, since 2012, following pioneering studies from Prof. Zhong Lin Wang, triboelectricity has become the object of intensive research worldwide. Moreover, since 2004, it has become relatively easy to synthesize materials consisting of just a single atomic layer, such as graphene. These so called 2D (two-dimensional) materials have impressively small thicknesses, e.g. below one nanometer (which is one million times smaller than a millimeter), and, therefore, have unique properties. Recently, a team of Korean and Italian researchers, led by Sang-Woo Kim (SKKU) and Christian Falconi (University of Rome "Tor Vergata") reported that by rubbing graphene, deposited on an insulating substrate, with an atomic force microscope, a part of the triboelectric charges can tunnel through the air-gap between graphene and the insulator and be stored on the insulator underneath graphene. Most remarkably, these stored charges can later control the properties of graphene itself. This mechanism, dubbed tunnelling triboelectrification, which is made possible by triboelectrification and by the ultimate, single-atomic thinness of 2D materials, could open the way to time-variant two-dimensional electronics where electronic devices and interconnects can be written, erased and re-written on demand. In the first paper, published on Nature Communications, the researchers already demonstrated rewritable devices ghost floating gates able to control the sign and polarity of charges in graphene and predicted that the approach could be extended to other 2D materials, which has later been confirmed by other researchers on MoS_2.

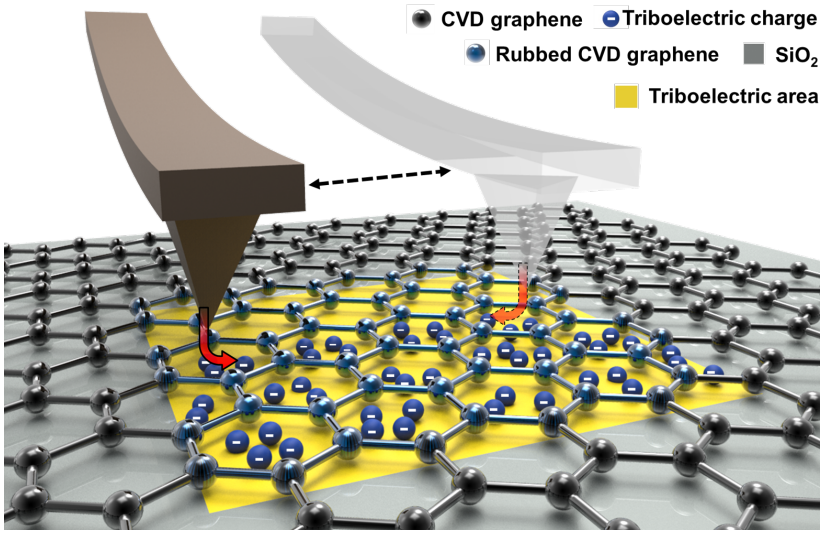

Figure 4: Schematic representation of the tunnelling triboelectrification process obtained by rubbing a graphene layer deposited on an insulator with the tip of an AFM (atomic force microscope).

Website: http://next.uniroma2.it

Researchers: Seongsu Kim, Tae Yun Kim, Kang Hyuck Lee, Tae-Ho Kim, Francesco Arturo Cimini, Sung Kyun Kim, Ronan Hinchet, Sang-Woo Kim, Christian Falconi.

FlowBlaze: Stateful Packet Processing in Hardware

The simple and very successful SDN match/action abstraction, defined by OpenFlow, is recently being challenged by new paradigms, such as P4 and Microsoft's Generic Flow Tables (GFT), based on the high level of flexibility and configurability of innovative hardware platforms. Since these paradigms are not suitable for the execution of stateful network functionalities, an ad-hoc dataplane pipeline called FlowBlaze has been developed. As shown in Figure 5, FlowBlaze extends the OpenFlow Match Action Table (MAT) pipeline. As in OpenFlow, packet headers (including packet metadata) are processed through the pipeline's elements to define the forwarding actions and packet operations. Each element can be either stateless or stateful. A stateless element is a MAT, similar to those of OpenFlow. Stateful elements implement an XFSM. As a result, a pipeline can combine both stateless and stateful elements. The architecture of a stateful element has the following elements: i) Flow Context Table, linking incoming packets to the corresponding set of state variables, ii) XFSM Table which evaluates the state transitions, iii) Update Functions, which update the state variables using arithmetic logic instructions, and iv) Action, which applies actions on the packet header. Since FlowBlaze is an abstraction that implements multiple XFSMs in hardware, it is a natural target to be configured by XL. XL (XFSM language) is a DSL (Domain Specific Language), developed in order to program stateful network functions, using an eXtended Finite State Machines (XFSM) abstraction. An XFSM is a finite state machine in which the state transitions are triggered by arithmetic/logic conditions evaluated on a set of state variables or asynchronous events, like timers and packets arrival. Each state transition can execute a set of actions to update the state variables and to apply network primitives to the packets. One of the main benefits of using XL, is having platform agnostic language, which gives to the programmer the ability of having a "code-once-port-everywhere" code, which can be executed, without changing it, on every platform able to execute an XFSM representation. Another characteristic of XL is its clear notion of state. In fact, for each network function, an explicitly flow-key is defined and a set of operations (lookup/update) are implemented to associate to each flow the corresponding state variables. In Summary, FlowBlaze allows implementing stateless and stateful network functions at high speed requiring (thanks to XL) no hardware design expertise.

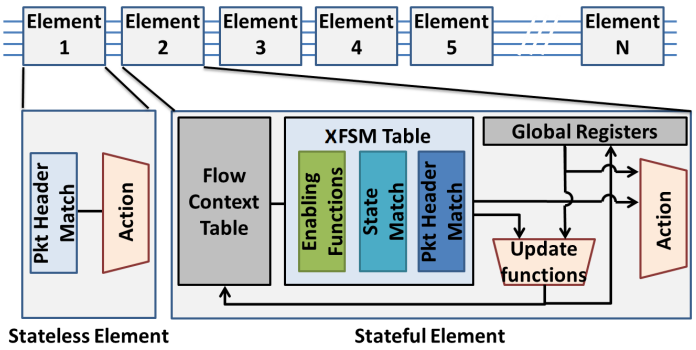

Figure 5: FlowBlaze architecture.

Website: http://netprog.uniroma2.it/flowblaze/

Researchers: Giuseppe Bianchi, Salvatore Pontarelli, Marco Bonola, Valerio Bruschi, Angelo Tulumello, Giacomo Belocchi, Aniello Cammarano.

Research and Innovation Projects

ChipScope: Overcoming the Limits of Diffraction with Super-Resolution Lighting on a Chip

The Opto- and Nano-electronics group is involved in the H2020 FET-Open project ChipScope. ChipScope will develop the scientific and technological basis for a completely new approach to optical super-resolution microscopy, with a resolution below the Abbé limit, based on semiconductor nanoLED arrays with individual pixel control, which will lead to extreme miniaturisation, simplicity and cost-effectiveness. One of the fields of application for such lens-less microscopes is living-cell observation. For this purpose, the developed nanoLED array and the photodetector will be integrated with a microfluidic system. A sketch of such a system is shown in Figure 6 a. Our group is responsible for the simulation and optimization of the nanoLED arrays, which are built by our partners at Technical University of Braunschweig. We use optical full-wave simulations to calculate the optical near and far fields above the LED array for a single activated LED, for which an example is shown in Figure 6 b. We have studied nanoLED arrays with a pitch down to 300 nm. As an important result, our simulations have shown that 3D patterned nanoLEDs, where the single LEDs are isolated by etching the semiconductor material, show considerable optical cross-talk. An important step in the design of sub-Abbé limit light emitters is therefore the optimization of the geometry in order to obtain localized light spots without cross-talk.

We have studied different approaches to reduce optical cross-talk, and elaborated design guidelines, which are now followed by our technology partners in the project. Preliminary simulations for an optimized structure, where we have introduced metallic nanospheres on top of the emitter array, have shown that it is in principle possible to reconstruct the position of the spheres with a resolution well below the LED pitch, that is below 300 nm, based on the intensity variations of the light detected by a single photodetector, when different nanoLEDs are activated.

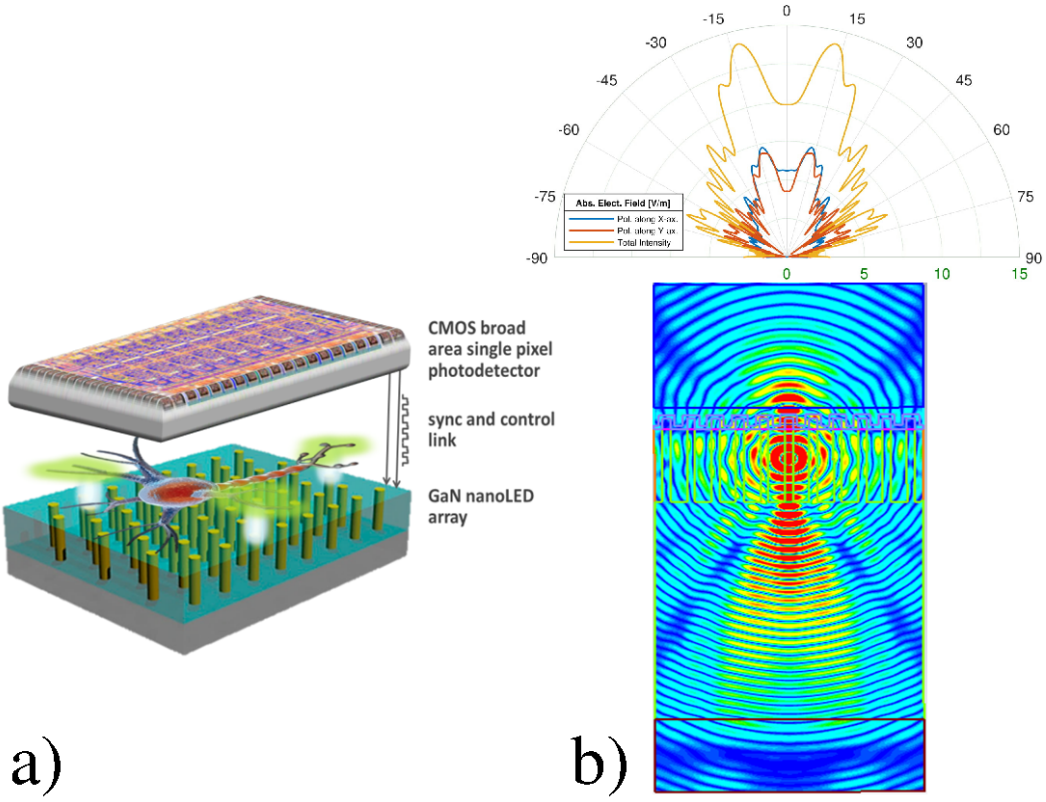

Figure 6: (a) schematic view of the proposed microscope. The individually controlled nanoLED are shown in the lower part. A sensitive single pixel photodetector at the top detects the light signal that has passed the object. (b) Electric field in an nanoLED array, with a single activated pixel. Light is emitted to the top, and intensity concentrated above the active pixel. The farfield emission pattern is shown on top.

Website: www.chipscope.eu

Researchers: Matthias Auf der Maur, Daniele Palazzo, Katarzyna Kluczyk, Aldo Di Carlo.

Noise Radar and Tailored Waveforms - Theory and Experiments in the NATO SET 225 Frame.

Noise Radar Technology (NRT) is nowadays a promising tool based on the transmission of waveforms made up by many noisy samples, which mitigate unwanted and wanted interference behaving as LPI (Low Probability of Intercept) and anti-spoofing signals. Each noisy sequence is theoretically uncorrelated with the others. Our research proposes the generation of a tailored pseudo-random sequences with high performances in terms of the Peak Side Lobe Ratio (PSLR) of the autocorrelation function, cross-correlation analysis to evaluate the orthogonality, bandwidth and energy efficiency. In particular, a new powerful cyclic algorithm (BLASA) has been developed which is able to strongly attenuate the range sidelobes of noisy signal while keeping their bandwidth within a given bound.

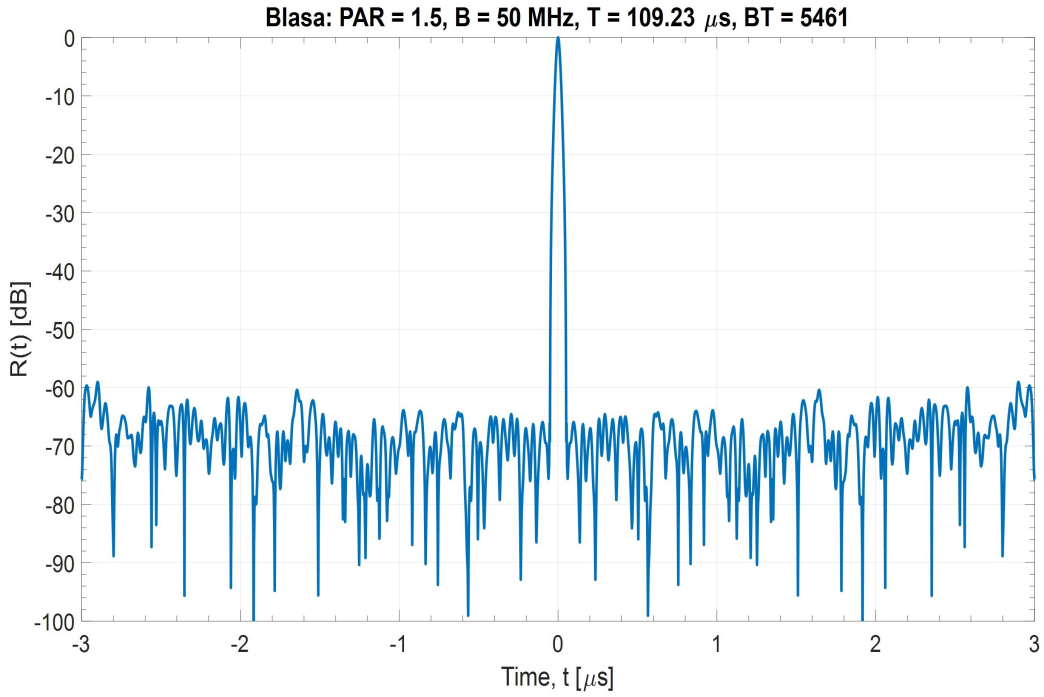

Figure 7: Normalized autocorrelation function of a waveform obtained by BLASA algorithm. $B = 50$ MHz, $T = 109$ μs.

Website: http://radarlab.uniroma2.it/wordpress/
Researchers: Gabriele Pavan, Gaspare Galati, Francesco De Palo, Christoph Wasserzier.

COPPER - Polymer Solar Cells for Agrovoltaic Applications

Photovoltaics and agriculture, a possible combination? For some years now people has been trying to couple the generation of electricity from renewable sources like the sun with agriculture. In this sense, the "agrovoltaics" was born, a new frontier that could alleviate the growing competition for agricultural land between food production and energy. Furthermore, the integration of photovoltaic in greenhouses could support the energy needs for the production of the underlying crops. If you think of the classic photovoltaic panels, you immediately associate the idea of a deleterious shadowing for everything that is grown below. However, some studies show that the design of a photovoltaic system that reduces the maximum solar radiation by 30% does not affect the qualitative and quantitative characteristics of the vegetable-floricultural production. Therefore, shading in greenhouses is not always critical. Indeed, it also represents a simple and economical method deliberately used to reduce the radiation and the temperature of air in greenhouses placed in particularly sunny and sultry contexts. To date, the Italian market is a niche sector and the systems installed are mostly solar tracking systems to maximize electricity production and minimize shading. Furthermore, there are case studies on greenhouses in which the cover is made up of thin-film photovoltaic panels, able to be receptive to light radiations in less stringent conditions than the classic panels. However, for all these solutions there are still doubts about the high investment costs and the landscape invasiveness of the plants. The Department of Electronic Engineering of the University of Rome "Tor Vergata" with the Centre for Hybrid and Organic Solar Energy (CHOSE) together with the Department of Agricultural and Forest Sciences of the University of Tuscia want to innovate and relaunch the agrovoltaics by introducing versatile, economical and non-invasive systems in which a photovoltaic technology a new concept is directly implemented in the flexible cover of agricultural greenhouses. The project, funded by the Lazio Region, plans to use organic photovoltaics based on printable inks that, unlike more traditional photovoltaic systems, offers the possibility of semi-transparency, mechanical flexibility, low cost and low environmental impact materials. Preliminary studies on lattuce cultivation have already shown that the shading of semi-transparent panels does not significantly affect the physiology, production and quality of greenhouse crops. Moreover, the project aims to clarify that the production of electric energy and the allowable shading could be changed according to the characteristics of the species, of the geography, of the meteorology, of the season and of the greenhouse.

The idea is therefore to develop a photovoltaic panel, light weight and foldable, to be unrolled according to needs. Furthermore, a covering of windows that presents a coating with selective materials to part of the solar radiation could induce the same effects that, to date, are recreated with the use of LED lamps, in order to stimulate plant growth and develop flowering and fruiting. The new prototype panels will be developed in the CHOSE by the group of Prof. Andrea Reale and tested in the Department of Agricultural and Forest Sciences by the team of Prof. Giuseppe Colla. The project also includes an experimentation phase at local farms.

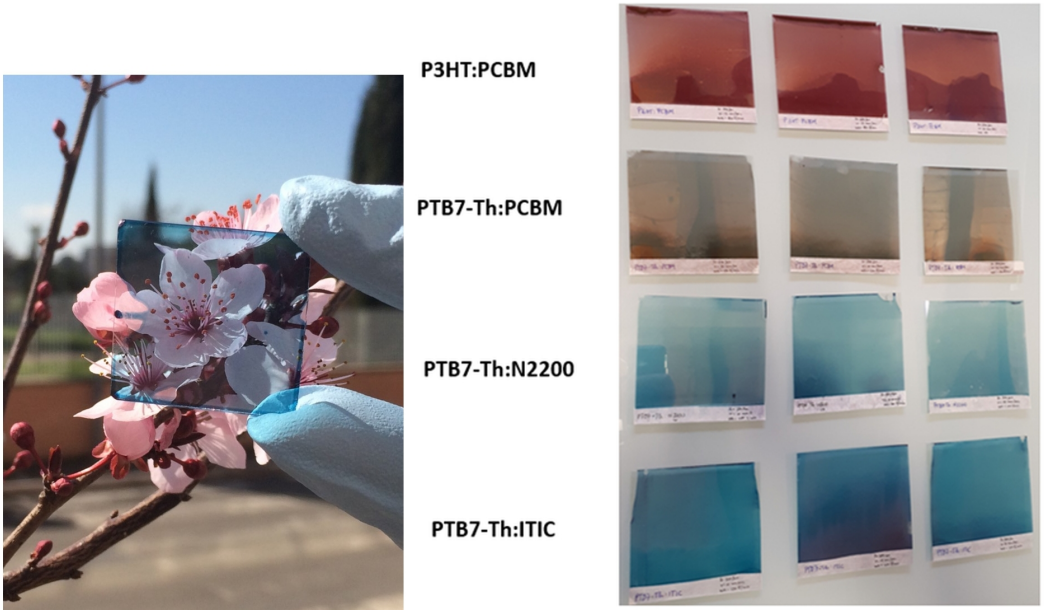

Figure 8: Semitransparent polymer solar cells based on organic polymeric semiconductors (OPV) are the core of the agrovoltaic functional substrates for PV over greenhouses.

Website: http://www.chose.uniroma2.it/en/
Researchers: A. Reale, R. Carcione, L. La Notte, R. Bedini, G. Colla.

Empowering GaN-on-SiC and GaN-on-Si Technologies for the Next Challenging Millimeter-Wave Applications (GANAPP)

The aim of this MIUR PRIN project is an in-depth analysis of the potential problems that may hinder the scaling of GaN HEMTs at or below 0.15 um. The latter include both basic issues, related with material properties and device physics, and concerns related with actual circuit implementation. As a final demonstration of the project, two Doherty power amplifiers for application in 5G systems, with state-of-the-art performance, will be designed and implemented in 0.15 um GaN-SiC and 0.1 um GaN-Si technologies. Significant improvements with respect to current state is anticipated for what concerns characterization and modeling of GaN parasitic effects, reliability physics, 2D device modeling, sub 150 nm GaN HEMT circuit models, MMIC design methodology. This project will also systematically study the reliability physics of scaled GaN devices; more accurate circuit-level models of GaN HEMTs will be developed, including trapping and thermal effects; new design-for-reliability methodologies will be implemented, based on the evaluation of actual stress imposed by RF operation. Project Partners: University of Padova, University of Ferrara, Polytechnic of Turin, University of Modena and University of Roma “Tor Vergata”.

Researchers: Rocco Giofré.

Satellite Communication and Propagation Experiments Through the Alphasat Q/V Band Technology Demonstration Payload

In 2004, ASI started to fund a program for the assessment of Q/V band satellite communications and in 2006 proposed to the European Space Agency (ESA), under the Alphasat program, to host an experimental payload in Q/V band aboard the new Alphasat geosynchronous Earth orbit (GEO) satellite. Following several technology studies and preliminary accommodation activities, the ASI Q/V band payload has been selected as one of the four hosted payloads, namely, technology demonstration payloads (TDPs), for flying on Alphasat. The payload development has been supported by ASI as a contribution to the Alphasat project, which is executed by ESA in the framework of the Advanced Research in Telecommunications Systems (ARTES) 8 Telecom program. Thales Alenia Space, Italy, and Space Engineering were the prime contractors for the development of the payload, named TDP 5.

The objective of the Q/V band TDP mission is to perform satellite communication experiment and propagation experiments (also referred to as the scientific experiment). The mission has been conceived by ASI with the support of Marina Ruggieri from University of Roma "Tor Vergata" as the principal investigator (PI) for the communication experiment, Carlo Riva, and the late Aldo Paraboni from Politecnico di Milano as PI of the propagation experiment. PIs have been responsible for providing ASI the scientific requirements for the development of Alphasat system and are responsible for the execution of the experiments. The ASI Q/V band payload was later renamed Aldo Paraboni payload in memory of the late Aldo Paraboni.

The aim of the communication experiment is to design, optimize and test the effectiveness of adaptive transmission schemes, i.e., PIMTs, over the Q/V band satellite channel. The aim of the propagation experiment is to characterize the behavior of the propagation impairments in Q/V bands satellite channels. These two experimental campaigns are obviously related and are jointly conducted. Alphasat was successfully launched on July 25, 2013, 19:54 Greenwich Mean Time, from the European Spaceport in Kourou (French Guiana) via the Ariane 5 ECA rocket. The orbit is inclined GEO (maximum) at the location 25^0 east. The in-orbit test campaign ended in December 2013. The experimental campaign started at the end of February 2014 and is currently ongoing.

Figure 9: Alphasat satellite carrying the Q/V band technology demonstration payload.

Website: artes.esa.int/news/alphasats-qv-band-payload-ready-action
Researchers: Tommaso Rossi, Mauro De Sanctis, Marina Ruggieri.

VIBES - Implementation of Virtualised Network Functions (VNFS) for Broadband Satellite Networks

The high-level project objective is to provide a tailored architectural and technological solution for performance optimization of end-to-end IP-based services, when a satellite component is present in the communication path. Target scenarios are compliant to upcoming 5G use-cases. VIBeS project reviews the role of Performance Enhancing Proxy (PEP) agents, redesigned as a set of Network Virtual Functions, namely NFV-PEP. In this innovative perspective, the NFV-PEP is following a top-down orchestration approach to flexibly satisfy the requirements of each application, on a slice basis. The proposed approach allows to pursue the following technical objectives:

- Rapid service innovation and then modifications through software-based deployment of functions, in order to satisfy possible evolving requirements;
- Improving operational efficiency through process and procedure automation, even allowing the possibility to transfer a PEP context for the sake of mobility;
- Greater flexibility on applying flow-specific rules, implementing methods to discriminate traffic by type, pattern, and performance requirements.

Project objectives will be verified through a Proof of Concept (PoC) real-time platform, reproducing a sub-set of significant converged 5G satellite-terrestrial scenarios:

- Satellite backhauling for traditional Web browsing from LTE/5G mobile users;
- Large-scale Web streaming services for fixed (i.e. ADSL) and mobile (i.e. LTE) users;
- Distributed M2M communications.

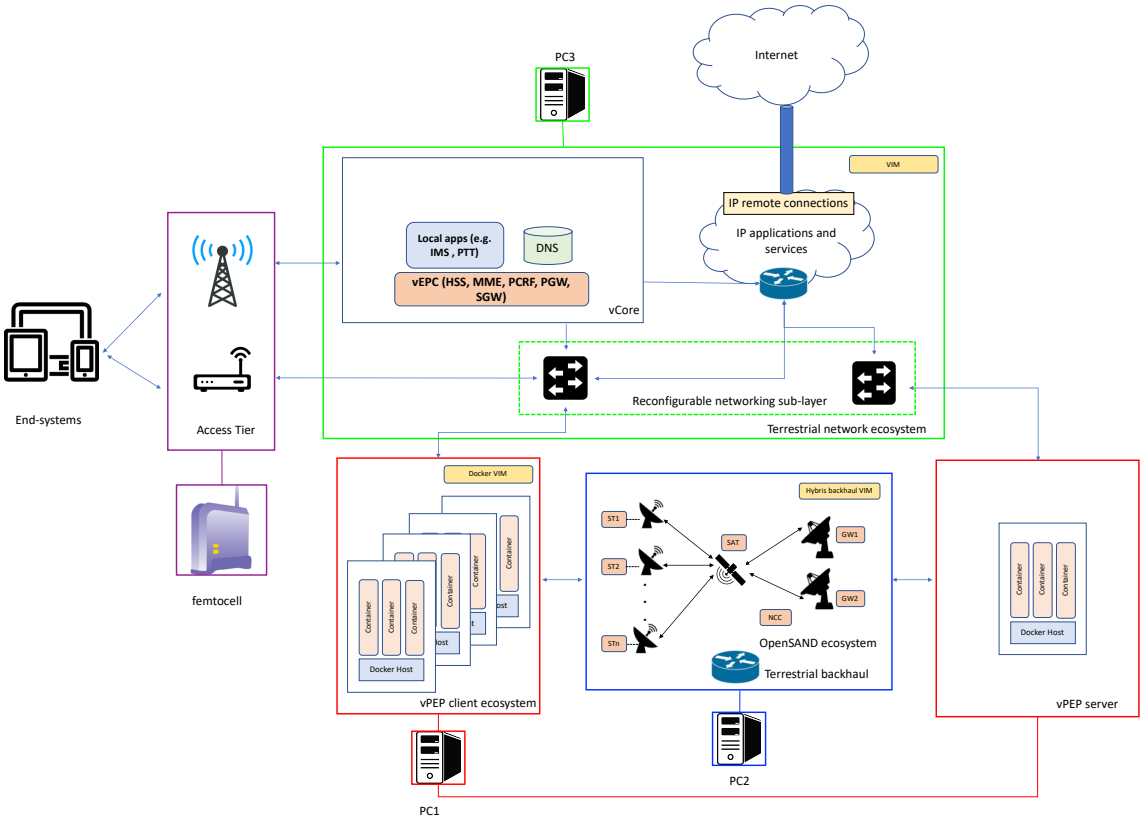

Figure 10: VIBES testbed architecture.

Website: https://artes.esa.int/projects/vibes
Researchers: Michele Luglio, Cesare Roseti, Francesco Zampognaro.

Dataplane HW-Compliant Programmability

The NetProg team is involved to design and implement data-plane ultra-high-speed (line-rate) programmable packet/flow processing technology, with specific attention to the relevant programming abstractions, devised with in mind seamless portability across different SW/HW platforms. This research project is today supported by the H2020 Project 5G-PICTURE: the explosive growth of mobile internet traffic introduces the need to transform traditional closed, static and inelastic network infrastructures into open, scalable and elastic ecosystems supporting new types of connectivity, high mobility and new mission-critical services for operators, vendors and vertical industries. 5G-PICTURE will develop and demonstrate a converged fronthaul and backhaul infrastructure integrating advanced wireless and novel optical network solutions to address the limitations of the current D-RAN and C-RAN approaches. But can we have flexibility and HW (line-rate) performance at the same time? Simply putting together: design and develop programmable switches and network interface cards which attain, at the same time, i) a full flexibility comparable to NFV, and ii) line-rate high-speed HW performance. However, our key requirement is portability, via the identification of platform-independent programming abstractions, permitting a write-once-port-everywhere network function coding, such that even a full-fledged protocol (e.g. TCP) or function normally executed on a commodity server could be seamless offloaded to an HW accelerated FPGA NIC or switch, with no SW re-coding effort whatsoever. As an example, within this project, a new abstraction has been developed: XTRA (XFSM for Transport). XTRA aims at providing a first attempt towards a "code-once-port-everywhere" platform-agnostic programming abstraction tailored to the deployment of transport layer protocols. XTRAs programming abstraction not only fits SW platforms, but is specifically designed to harness, with no re-coding effort, the offloading opportunities offered by CPU-less HW boards or smart NICs. We demonstrate the viability of XTRA with three completely different implementations of the underlying abstraction execution engine (HW proof-of-concept on a NetFPGA board, User-space SW over Linux Open Data Plane, and NS3 emulator). Flexibility is shown via a number of example applications, ranging from a variety of congestion control algorithms, to a middlebox-type TCP proxy functionality, up to a customized "Timer-Based" (TB) TCP which leverages the native reliance of XTRA on timers, so as to produce a loss recovery operation which, despite being formalized only via a handful of code lines, performs almost comparable with the highly optimized Linux and FreeBSD implementations.

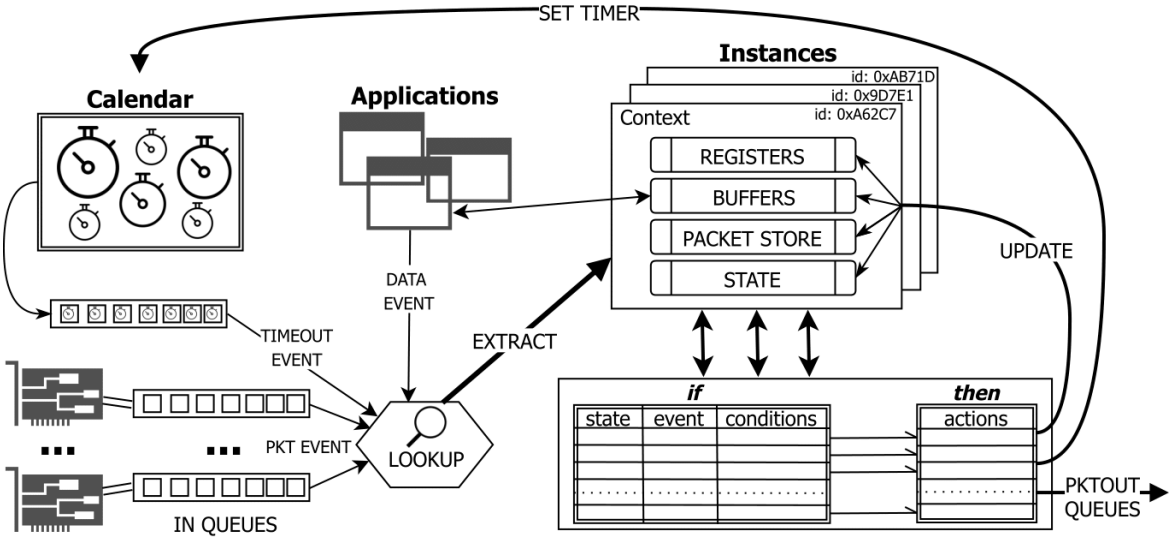

Figure 11: XTRA in a nutshell.

Website: http://netprog.uniroma2.it/

Researchers: Giuseppe Bianchi, Salvatore Pontarelli, Marco Bonola, Valerio Bruschi, Angelo Tulumello, Giacomo Belocchi, Aniello Cammarano, Marco Faltelli, Marco Spaziani Brunella, Alessandro Palumbo.

Master of Science in Mechatronics Engineering

Modern productive needs require integrated expertises in Mechanics, Electronics and Automation, both for traditional mechanical and electronical applications and for new mechatronical products, where it is hard to separate mechanical and electronical features and where an end-to-end management approach is strictly required (Flexible production systems, in the case of 3D printers and robotics). For these reasons, following a new formative approach, the Department of Electronics Engineering of the University of Rome "Tor Vergata" has created a new Course of Masters Degree in Mechatronics Engineering. This new course is based on the fundamental disciplines: Electronics, Mechanics and Automation with subjects headed to the embedded development of a mechatronic system. The course is completely taught in English and it has the following tasks:

- Promoting internationalization (thanks to many cooperations with national and international industries and universities);
- Promoting the enrollment of students with different backgrounds;
- Reinforcing the leading economical and technical role of Mechatronics;
- Creating new job opportunities for an innovative kind of engineer.

The course of study in Mechatronics Engineering is based on experimental and laboratory experiences, in order to focus on the application of basic disciplines for the solution of all the complex problems in the domain of Engineering. The Masters Degree in Mechatronics Engineering is organized in three different areas which integrate both the background and the specific interests of students. As for the future job and career outlook, Mechatronics Engineering offers several opportunities: Energy systems, Environmental and Health sectors, Mechatronical systems for Industry, Space and Security. The Mechatronic Engineer will be able to work for the design, the management and the maintenance of these systems.

Bachelors Degree and Masters Degree in Electronics Engineering

It is one of the most memorable courses in Italy. It is organized in a three-year Bachelors Degree and a two-year Masters Degree. The task of the Bachelors Degree is to provide students with a solid basic background and with a suitable knowledge to face professional activities connected with the different cores of Electronics in its different domains (design, production, management, support) both in public and in private manufacturing and services structures. In the same sectors, the Masters Degree focuses on more specific tasks towards innovation, research, advance design, complex system management. As Electronics is getting more and more pervasive, this Course of Study is a solid investment for the future. The occupational rate is at its highest level; graduate students are sought-after and they can choose among many offers. Many graduate students carry out jobs which require accountability in important national and international industries and they are appreciated for their competence. The didactic offer of the Masters Degree is organized in five areas, covering all the fields of the current market request: Energy, Health and Environment, Industry, Space and Security, Telecommunication and Multimedia. The teaching system includes both traditional taught classes and practice exercise in laboratories, high level workshops, for the best development of a students knowledge and competence. The main characteristic of this Course of Study is a constant and continuous monitoring and improvement of the quality of procedures, of

services and of teaching, enhancing the students involvement. Further information for the enrollment procedure, for enrolled students, for graduate students and for industries too are on the website: elettronica.uniroma2.it

Bachelors Degree and Masters Degree in Internet Engineering and in ICT and Internet Engineering

Internet and the development of mobile communcations have changed our way of working and confronting, realizing the biggest revolution in our age. Smartphones, Social Media like Facebook, communication platforms like Whatsapp have changed our way of living. The so-called Internet of Things (IoT) represents the current further revolution. Dozens of billions of interconnected devices will be able to realize services for Smart Homes, for industrial or working automation, (Industry 4.0 Smart Offices), for Self-Driving Cars, for Smart Cities and for E-Health. Those services are based on basic technologies to measure and transmit distance information (through cables and radio waves). Basic technologies are combined with systems and infrastructures (cellular networks) which allow the realization of services. In this new scenario cyber-security is fundamental. The Bachelors Degree in Internet Engineering and the English taught Masters Degree ICT and Internet Engineering pursue the task to train new engineers to design and develop new basic technologies and systems and to use them, designing and managing infrastructures and services of the Internet of the future. For the moment, the demand for professionals is higher than the supply. The Internet Engineer is the profession of the future and it represents one of the most interesting job opportunities. The Bachelors Degree offers three research programmes (Internet of Things, CyberSecurity, Communication Technologies); the Masters Degree is organized in three thematic areas (Sensing & Communications, Network & Security, Data Analysis & Methodologies). For further information, please visit the web site internet.uniroma2.it

News from the Graduate and Undergraduate Programs

Teachers of “Vulnerability and defense of Internet Systems”, taught in the Bachelors Degree Internet Engineering, had a specific and important role in the first edition of Cy4games Capture the Flag on Trial, which took place on May 6, 2019, in Rome at the headquarters of Elettronica Group. The technical organization of the event in the form of a competition “Capture the Flag” in a simultaneous mode Attack & Defense (each team had to attack and defend at the same time the other teams) required specific and unique devices developed for the occasion. Our teachers have conceived, designed and realized the 5 challenges for the teams, including service and Computer Science vulnerability, a challenge based on cryptographic techniques and a further challenge focused on reversing and exploitation of applications. Even ten students, divided in two teams, from the Course of Study in Internet Engineering took place in the competition. Although, these students were only at the beginning of their studies, one team succeeded in reaching half the placement, an eminent result considering the national level of the whole competition. Teams from many regions of Italy took place in the competition (Trento, Milan, Catania) which was won, for the record, by the team from Perugia.

Upcoming Events

- **Event:** Second edition of the International Symposium on Advanced Electrical and Communication Technologies (ISAECT 2019), www.isaect.org.
  Date: November 27 29, 2019.
  Venue: Rome, University of Rome "Tor Vergata", Department of Electronics Engineering.

- **Event:** IEEE International Workshop on Metrology for AeroSpace (MetroAeroSpace), (www.metroaerospace.org)
  Date: June 19 - 21, 2019.
  Venue: Torino (Italy).

- **Event:** International Radar Symposium IRS 2019, (www.dgon-irs.org)
  Date: June 26 - 28, 2019.
  Venue: Ulm (Germany).

- **Event:** International Ph.D. School of the Societ Italiana di Elettronica (SIE).
  Date: June 24 - 26, 2019.
  Venue: Rome, University of Rome "Tor Vergata", Department of Electronics Engineering, Leonardo classroom.

- **Event:** Signal Processing Symposium 2019, (spsympo.ise.pw.edu.pl)
  Date: September 17 - 19, 2019.
  Venue: Krakow (Poland).

- **Event:** The Department of Electronics Engineering will take part in the monthly event called "Porte Aperte" where our Teachers will have the opportunity to present the Bachelors Degree courses in Electronics Engineering and in Internet Engineering and the Masters Degree courses in Electronics Engineering and in ICT and Internet Engineering to all those students who are searching for more information about the didactic offer of the Department, before enrolling.
  Date: July 18, 2019, from 9:30 to 13:00.
  Venue: Aula Magna of the School of Economics, University of Rome "Tor Vergata".

Seminars and Invited Lectures

Prof. Andrea Reale received the invitation to present an invited lecture at 20th International Conference on Physics of Light-Matter Coupling in Nanostructures - PLMCN that will be held in Moscow & Suzdal (Russia) from 2nd to 6th July 2019, to presents CHOSE activities on "Printable Organic Photovoltaic Devices Based on CVD Graphene Transparent Electrodes".

Achievements

- "EuRAD Young Engineer Prize" to Francesco De Palo, 2017 Nuremberg (Germany).
- "Best Paper Award" to M. Luglio, C. Roseti, E. Russo, F. Zampognaro, "Feasibility of 5G services over Ka-band Athena-Fidus satellite", Proceedings of the 14th International Joint Conference on e-Business and Telecommunications (ICETE 2017) - Volume 3: DCNET (8th International Conference on Data Communication Networking), ISBN 978-989-758-256-1, pages 33-42, Madrid, Spain, 24-26 July, 2017.
- "Best Poster Award" to A. Pallotti, M. Ricci, G. Orengo, G. Saggio, "Low Cost and Fast Development of 3D Printed Gloves for 10 Degrees of Freedom Gesture Recognition", BIODEVICES 2019.
- On May 16th, 2019, the former student Cinzia Silvestri received from the Coordinator of the Course in Electronic Engineering prof. Marcello Salmeri, at the hands of the student representative Elisa Nonni, a certificate of merit "for the results achieved in the workplace, research and innovation that have brought prestige to the course". At the same time, Cinzia Silvestri held a seminar to illustrate the activities of the start-up BI/OND of which she was the founder and at the present is CEO, and whose results contributed to being included by Inspiry Fifty among the 50 most influential Italian women in the fields of innovation in 2018.
- 3rd place @the ACM SIGCOMM Student Research Competition 2018, Angelo Tulumello.

Recent Publications

- A. Di Vito, A. Pecchi, A. Di Carlo, M. Auf der Maur, "Characterization of non-uniform InGaN alloys: spatial localization of carriers and optical properties", Japanese Journal of Applied Physics, Volume 58, Number SC, 2019.
- D. Rossi, F. Santoni, M. Auf Der Maur, A. Di Carlo, "A Multiparticle Drift-Diffusion Model and its Application to Organic and Inorganic Electronic Device Simulation", IEEE Transactions on Electron Devices, vol. 66, no. 6, pp. 2715-2722, June 2019.
- J. Gulink, S. Bornemann, H. Spende, M. Auf der Maur, A. Di Carlo, J. Daniel Prades, H. Suryo Wasisto, A. Waag, "InGaN/GaN nanoLED Arrays as a Novel Illumination Source for Biomedical Imaging and Sensing Applications", Proceedings of Eurosensors 2018.
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- D. Di Giuseppe, F. Corsi, A. Mencattini, M. C. Comes, P.Casti, C. Di Natale, L. Ghibelli, E. Martinelli, "Learning cancer-related drug efficacy exploiting consensus in coordinated motility within cell clusters", IEEE Transactions on Biomedical Engineering, in press.
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- S. Di Domenico, M. De Sanctis, E. Cianca, F. Giuliano, G. Bianchi, "Exploring Training Options for RF Sensing Using CSI, IEEE Communications Magazine, vol. 56, no. 5, May 2018.
- T. Rossi, M. De Sanctis, F. Maggio, M. Ruggieri, C. Hibberd, C. Togni, "Smart Gateway Diversity Optimization for EHF Satellite Networks," in IEEE Transactions on Aerospace and Electronic Systems, in press.
- A. Abdelsalam, M. Luglio, C. Roseti, F. Zampognaro, "TCP Wave: a new reliable transport approach for Future Internet", Computer Networks, vol. 122, January 2017.
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- G. Galati, G. Pavan, (Invited Paper) "High Resolution Measurements and Characterization of Urban, Suburban and Country Clutter at X-Band and Related Radar Calibration", Proc. 9th International Conference on Ultrawideband and Ultrashort Impulse Signals (UWBUSIS), 4 - 7 September 2018, Odessa (Ukraine).
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