The Newsletter of the
Department of Electronics Engineering

TOR VERGATA
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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 Bachelor's Degree and Master's 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 Bachelor's Degree, three Master's 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 once 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 second issue of the Newsletter of the Department of Electronics Engineering, "Tor Vergata" University of Rome. Regardless of the pandemic storm that is affecting our everyday life, research activities at the Department progressed steadily and new achievements can be presented to your attention. As in the inaugural issue, the newsletter is opened by the keynote address, gently provided by Massimiliano Ladovaz, heading the engineering teams and satellite operations at OneWeb. Space-related research is indeed one of the key directions followed historically at the EE Dept., as demonstrated in this issue by the four H2020 and ESA research project also presented in the issue. Mega-constellations and the associated challenges provides us therefore a well-defined and interesting direction. The issue contains research spotlights also on very hot topics regarding 5G, perovskite solar cells, LTE use for crowd density estimation and reinforcement learning: diversified yet interconnected research topics that exemplify the vitality and in-depth competences available in the department. As a further international R&I project, SMILE aims at developing a fully scalable microLED platform allowing hybrid integration with CMOS microelectronics. Finally, a short description of the BS and MS courses managed by the EE Dept. is provided, underlining the link, that has always to remain as tight as possible, between our research and our students. A Section including the main upcoming scientific events in which our researchers are involved is included: most of them are of the virtual type, opening up the possibility to easily attend!

Enjoy reading !

Ernesto Limiti, Director of the Electronics Engineering Department

Keynote Address

Sustainability of Future Space Information Networks

Recent years have seen the introduction of a new era of commercial space activity, driven by advancements in technology, increases in private investment, and reductions in satellite manufacturing and launch costs. Small satellites are being launched in unprecedented numbers, and proposals for large, Low Earth Orbit (LEO) constellations are becoming a reality. In 2017, the number of satellites launched to LEO altitudes topped 400, more than double the number launched just one year earlier, the number nearly doubled again in 2020. This new era of space activity is expanding space-based global communications, remote sensing, and a host of novel services that promise new opportunities for economic development, global education, rural healthcare, location-based services, and advancements in environmental science. However, this era is also marked by elevated concerns over space sustainability and the safety risks posed by an increasingly congested operating environment. Space surveillance networks now track more than 23,000 objects in Earth orbit, and unseen are nearly a million, "lethal non-trackable" (LNT) fragments that are too small to be cataloged but still possess enough impact energy to disable a satellite.

Collision avoidance has received much of the attention in recent years, with many focusing on improvements in Space Situational Awareness (SSA), Space Traffic Management (STM), and coordination between operators. And while these all contribute to safety, overall mission-terminating collision risk for a satellite in LEO is dominated by debris that is too small to be mitigated by active collision avoidance measures. Our only option for addressing this risk is to prevent the generation of small debris in the first place. We can do this by designing and operating future missions in ways that do not pollute, and by removing large, derelict objects from the environment before they have an opportunity to explode or collide with other objects. Removal is an expensive and technically daunting prospect, yet it is becoming increasingly clear that this will be a necessary component of environmental management. This makes it all the more imperative that spacecraft and launch vehicle operators adopt responsible design and operational practices. This is by far the most cost-effective means of limiting debris creation and ensuring the safety and sustainability of future space operations.

Tying safety requirements to national market access licenses is an effective way to encourage higher standards from every operator wishing to provide in-country services, regardless of the jurisdiction that issued the operator its launch and operations license, or that sponsored the operator's spectrum authorisation with the ITU. This also creates a more level playing field for domestic industry by requiring the same attention to safety from foreign systems as is required from local players. It also allows a national administration to uphold high standards in its own industry without fear of chasing applicants to more lenient jurisdictions.

France has already demonstrated to the world that strict adherence to debris mitigation rules does not negatively impact national industry. French law requires all of its space actors (satellite manufacturers, satellite operators, and launch vehicle service providers) to adhere to its debris mitigation rules, with no evidence of stifling competitiveness or innovation. Furthermore, it has reflected well on the French space agency (CNES) as a thought-

leader and earned them respect and influence with the UN, the IADC, and ESA, as well as with international standards and professional organisations.

Advocating for better, more uniform safety practices does not require draconian measures and overly burdensome or overly prescriptive regulation. It simply requires a fresh assessment of the industry trends and practices, and suggests that operators be held accountable for their behaviour. Toward these goals, principal safety themes include:

- Reliability: satellites should be subjected to rigorous ground qualification programs, particularly when developing large satellite systems.
- Control: operators should be responsible for being able to identify their assets, know where they are, and control their trajectories.
- Coordination: operators should share orbit information and maneuvering plans with other operators and coordinate to avoid collisions.
- Disposal: upon decommissioning LEO operators should promptly, reliably, and safely deorbit their hardware.
- Safety-by-Design: orbits and constellation configurations should be selected to minimise risk.

A new era of space commercialization is already upon us and can improve lives in a number of important ways and solve present day challenges. The existing regulatory frameworks however do not support responsible growth of this industry. Leaders have an opportunity to see new services realized, businesses grow while also ensuring it is done safely and sustainably.

Several operators like OneWeb are advocating for "Responsible Space" and implementing the necessary measures to prevent debris in space, that include high reliability designs, implementation of "grappling fixtures", developing active debris removal solutions but for a real solution a consistent approach by all operators is necessary, by doing that we will protect a limited resource.

Massimiliano Ladovaz

Massimiliano Ladovaz heads the engineering teams and satellite operations at OneWeb. He is responsible for the next generation of system infrastructure aspiring to achieve outstanding technical solutions and innovation. He leads the R&D, design, manufacture and delivery of OneWeb's satellites, launch programme, systems, ground and user terminal engineering as well as satellite operations. OneWeb's mission is to enable internet access everywhere, for everyone. OneWeb is building a communications network with a constellation of Low Earth Orbit satellites that will provide connectivity to billions of people around the world. OneWeb is creating business solutions for Broadband, Government and Cellular Backhaul. It's high speed, low latency, network will offer game-changing mobility solutions to industries that rely on global connectivity, such as Aviation, Maritime, Automotive, Trains and more. *OneWeb* will enable connectivity for governments, businesses, and communities. It is implementing a constellation of Low Earth Orbit satellites with a network of global gateway stations and a range of user terminals to provide an affordable, fast, high-bandwidth and low-latency communications service, connected to the IoT future and a pathway to 5G for everyone, everywhere.

Research Spotlights

Performance tuning of Perovskite solar cells by addition of 2D transition metal carbides

During the last decade, organometal halide perovskites have moved into the focus of the photovoltaics research community due to the excellent properties of this material class. It combines advantages of organic materials (cost effective processing technology, abundance of raw materials) with that of inorganic semiconductors (crystalline structure, good charge transport) and allowed to reach in only roughly 10 years a record efficiency of 25.2%, higher even to thin-film silicon technology. In the last years, research has been concentrating to large extent on approaching the maximum possible power conversion efficiency, for which an important ingredient is the optimization of the open circuit voltage. For this, tuning of the work functions and energy alignments is of paramount importance. Ways to do this include proper materials choice, but also targeted modification of given materials. In collaboration with the National University of Science and Technology 'MISiS' in Moscow, Russia, and with CNR and the INFN, a systematic combined experimental and computational study on the effect of 2D transition metal carbides with chemical formula Ti3C2Tx, known as MXenes, as additives in the different layers in Perovskite solar cells has been performed. A main result of the work is the observation, that the low work function of the MXenes can substantially modify both the work function of the materials they are added to, but also engineer the relative alignment of the energy levels at material interfaces, even for very low percentages of added MXene. This has been deduced by direct measurement of work functions by means of photoelectron spectroscopy, and by comparing numerical simulations with measured device and material characteristics. Experimentally, different cells with systematic addition of MXene in the different layers or at interfaces have been produced and characterized, leading in combination with material characterization and simulation to a clear understanding of the effect of MXene additives, and therefore to recipes on how to improve Perovskite solar cell performance. In fact, in this work an increase from roughly 17% to 19% of power conversion efficiency has been reached by proper distribution of additives. These results have been published in Nature Materials.

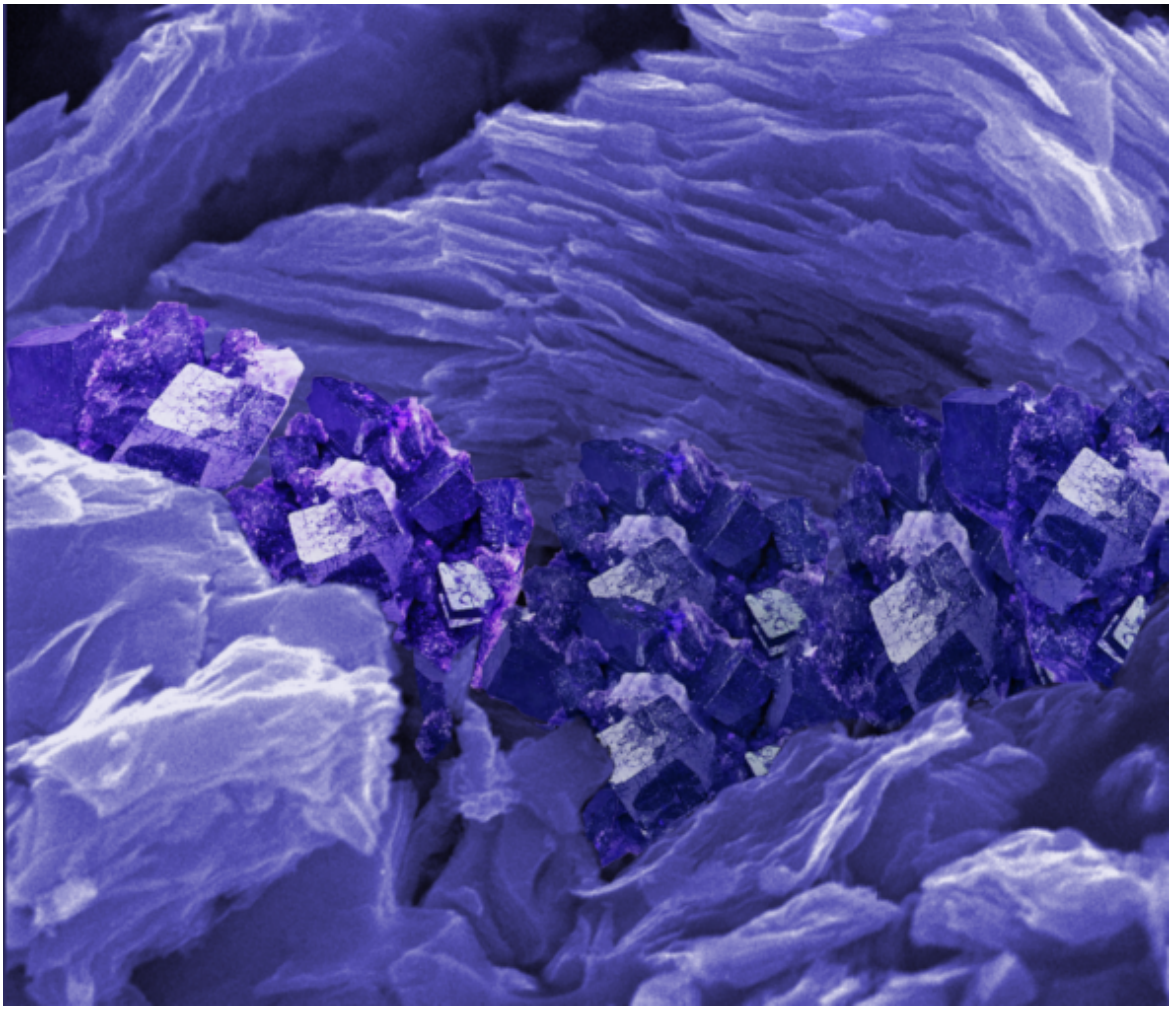

Figure 1: Scanning electron microscopy view of Perovskite crystals embedded in MXene flakes.

Researchers: A. Agresti, S. Pescetelli, A. Di Vito, D. Rossi, M. Auf der Maur, A. Di Carlo.

Device-Free Crowd Density Estimation Using LTE Signals

We proposed a novel approach for passive device-free crowd density estimation, based on Channel State Information (CSI) extracted from LTE synchronization signals transmitted by an eNodeB. The novel approach proposed in this paper exploits the Singular Value Decomposition (SVD) of the CSI secant set. SVD has been extensively used in RF sensing systems to reduce the unstability of the collected data due to noise or HW imperfections. On the other hand, the proposed method uses all components of the SVD. In particular, features are extracted from the sorted list of singular values, which has been demonstrated to be strongly correlated to the number of people in the monitored room. The performance of the proposed approach has been assessed assuming a number of people ranging from 0 to 17, achieving an average accuracy of 84%. This is a very promising result, which confirms the feasibility of the proposed crowd density estimation through LTE signals, whose performance is comparable with the ones of more extensively studied WiFi based system. The use of LTE for crowd density estimation widens the possibility to use passive RF-sensing also in indoor or outdoor scenarios where WiFi is not available, such as small train stations or city squares.

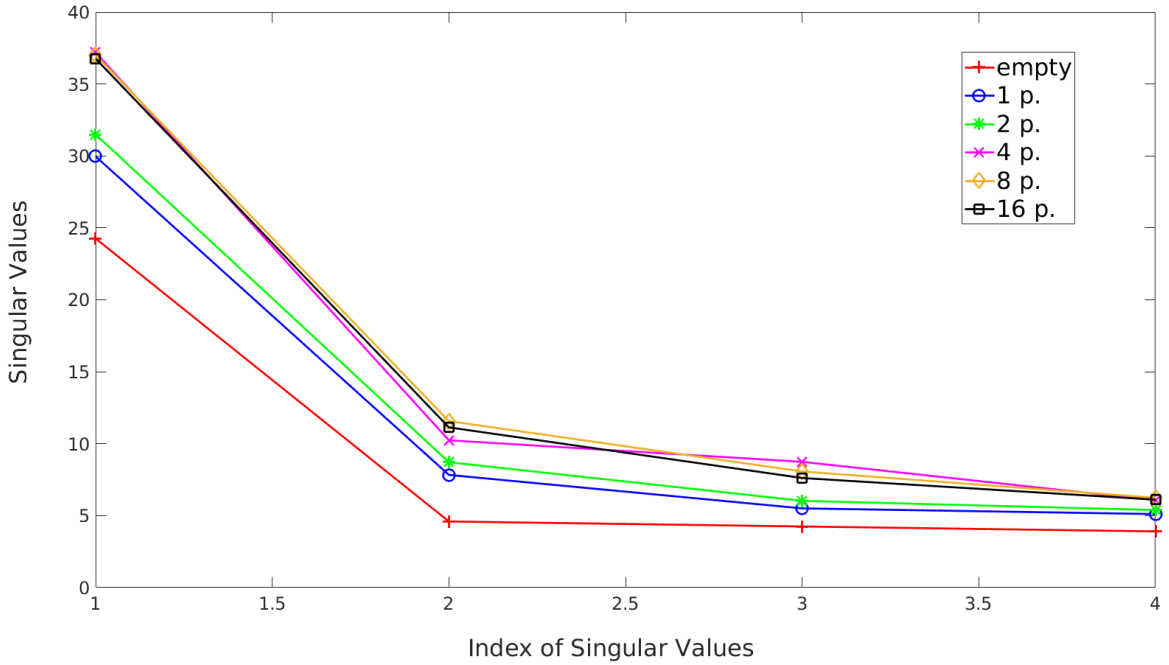

Figure 2: List of singular values for different number of people.

Website: www.radiopoints.it
Researchers: M. De Sanctis, T. Rossi, S. Di Domenico, E. Cianca, M. Ruggieri.

Reinforcement learning as a flexible tool for dynamic environments

In the field of Machine Learning (ML), Reinforcement Learning (RL) is a learning approach based on a trial & error process which is very similar to the human learning. In contrast to Supervised Learning, the training examples are in the form -input-correct output-, the "examples" in RL are in the form -input-some output-reward for the specific output. This is an area of ML concerned with how agents ought to take actions given a state in an environment so to maximize some notion of cumulative reward (Fig. a). The choice of this techniques is optimal in the case of dynamic environments. RL presents some advantages over traditional ML techniques:

- Dataset not required, so the training is not biased.
- The Training and Inference phases are merged with a suitable balance of environment Exploration and Exploitation.
- The agent adapts itself to a dynamic context.

Due to its flexibility, RL can be used to solve a large variety of problems and to perform very complex tasks. Applications of RL vary from robotic control, telecommunications, to Internet of Things (IoT). In the last years, a new research field based on swarm and multi-agent RL applications and algorithms saw a growth in the literature. This approach allows the group of agents to cooperate in solving their task but also to share the knowledge gained by the exploration of the environment. The DSPVLSI group is actively working on new applications and implementations of RL algorithms. Recently, we presented an optimized multi-agent RL algorithm: Q-RTS (Q-Learning Real Time for Swarms). It is based on the well-known Q-Learning algorithm and it is able to control in real-time swarm of robots. Q-RTS is the algorithm that drives our TorVerBots (Fig. b), a swarm of intelligent agents that explores the environment sharing their knowledge to speed-up the learning process. Our group also employed Q-Learning to solve classical communication tasks such as the synchronization of PSK and QAM transmissions (Fig. c). The advantage of the obtained system is its ability to adapt itself to the variation of the channel and the modulation scheme without changing the architecture. This happens seamlessly without any action required from the user. Since the problems that can be solved by using RL are more and more complex, we also designed a parallelized hardware accelerator for Q-Learning and SARSA algorithms, the two most used Time-Difference based RL techniques. Our architecture is focused on low-power applications such as IoT and smart-sensor networks and showed great computational performance while requiring very low hardware resources. RL can be considered the new frontier for dynamic systems since it exceeds the performance of most traditional approaches in a large number of applications.

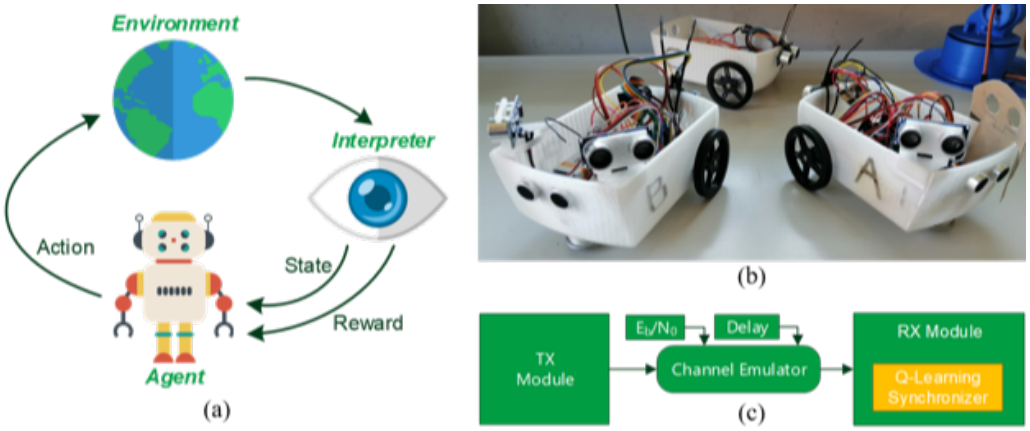

Figure 3: (a) Reinforcement Learning framework. (b) TorVerBot swarm for environmental exploration. (c) PSK/QAM telecommunications synchronizer based on Reinforcement Learning.

Website: dspvlsi.uniroma2.it

Researchers: Gian Carlo Cardarilli, Luca Di Nunzio, Rocco Fazzolari, Daniele Giardino, Marco Matta, Marco Re, Sergio Spanò.

Health Risks Associated with 5G Exposure: A View from the Communications Engineering Perspective

The deployment of the fifth-generation (5G) wireless communication services requires the installation of 5G next-generation Node-B Base Stations (gNBs) over the territory and the wide adoption of 5G User Equipment (UE). In this context, the population is concerned about the potential health risks associated with the Radio Frequency (RF) emissions from 5G equipment, with several communities actively working toward stopping the 5G deployment. To face these concerns, in this work, we analyze the health risks associated with 5G exposure by adopting a new and comprehensive viewpoint, based on the communications engineering perspective. By exploiting our background, we debunk the alleged health effects of 5G exposure and critically review the latest works that are often referenced to support the health concerns from 5G. We then precisely examine the up-to-date metrics, regulations, and assessment of compliance procedures for 5G exposure, by evaluating the latest guidelines from the Institute of Electrical and Electronics Engineers (IEEE), the International Commission on Non-Ionizing Radiation Protection (ICNIRP), the International Telecommunication Union (ITU), the International Electrotechnical Commission (IEC), and the United States Federal Communications Commission (FCC), as well as the national regulations in more than 220 countries. We also thoroughly analyze the main health risks that are frequently associated with specific 5G features (e.g., multiple-input multiple-output (MIMO), beamforming, cell densification, adoption of millimeter waves, and connection of millions of devices). Finally, we examine the risk mitigation techniques based on communications engineering that can be implemented to reduce the exposure from 5G gNB and UE. Overall, we argue that the widely perceived health risks that are attributed to 5G are not supported by scientific evidence from communications engineering. In addition, we explain how the solutions to minimize the health risks from 5G (including currently unknown effects) are already mature and ready to be implemented. Finally, future works, e.g., aimed at evaluating long-term impacts of 5G exposure, as well as innovative solutions to further reduce the RF emissions, are suggested.

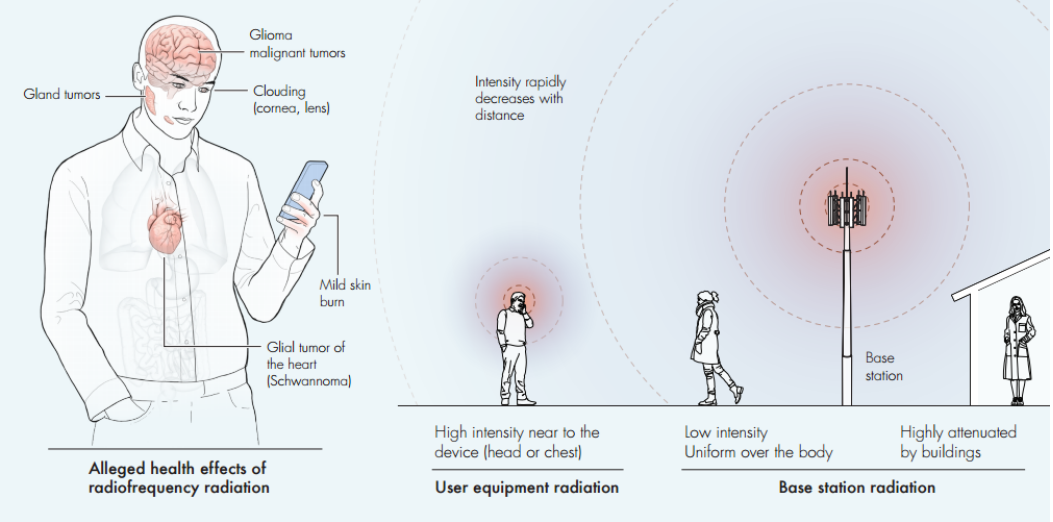

Figure 4: Left part: main health effects alleged by the population, due to the exposure from Radio-Frequency (RF) devices (including 5G equipment). Glioma and Schwannoma tumors have been observed only in animals exposed to high levels of ElectroMagnetic Field (EMF). Right part: the primary sources of EMF exposure when considering mobile network equipment. The EMF exposure from User Equipment (UE) tends to be higher and more localized on the body than the one from radio base stations. Moreover, the EMF intensity rapidly decreases as the distance between the base station and the user is increased. Finally, buildings introduce a shielding effect that attenuates the exposure from outdoor base stations. (Copyright notice: the figure was produced by Xavier Pita, scientific illustrator at King Abdullah University of Science and Technology (KAUST)).

Researchers: Luca Chiaraviglio (Uniroma2), Ahmed Elzanaty and Mohamed Slim Alouini (KAUST).

Will the Proliferation of 5G Base Stations Increase the Radio-Frequency "Pollution"?

A common concern among the population is that installing new 5G Base Stations (BSs) over a given geographic region may result in an uncontrollable increase of Radio-Frequency "Pollution" (RFP). To face this dispute in a way that can be understood by the layman, we develop a very simple model, which evaluates the RFP at selected distances between the user and the 5G BS locations. We then obtain closed-form expressions to quantify the RFP increase/decrease when comparing a pair of alternative 5G deployments. Results show that a dense 5G deployment is beneficial to the users living in proximity to the 5G BSs, with an abrupt decrease of RFP (up to three orders of magnitude) compared to a sparse deployment. We also analyze scenarios where the user equipment minimum detectable signal threshold is increased, showing that in such cases a (slight) increase of RFP may be experienced.

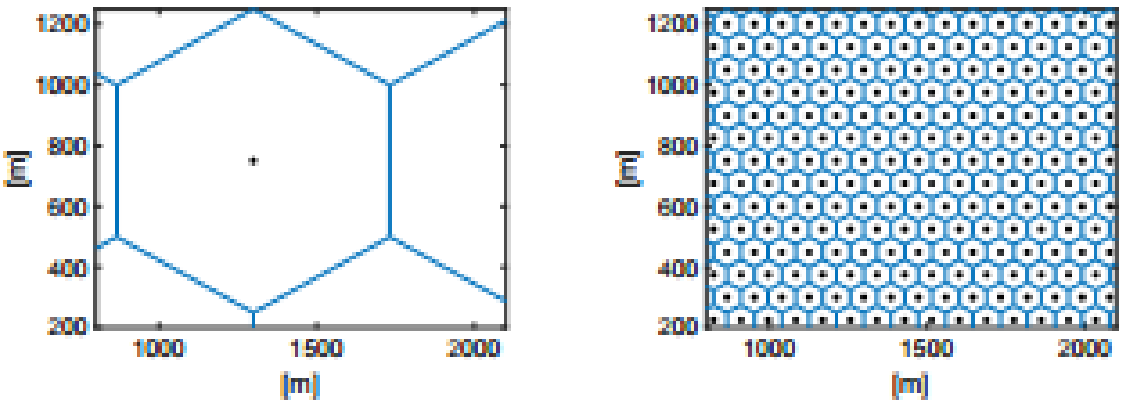

Figure 5: Two examples of candidate cellular network layouts taken under consideration in the work.

Researchers: Luca Chiaraviglio, Giuseppe Bianchi, Nicola Blefari Melazzi (Uniroma2) and Marco Fiore (IMDEA Networks, Spain).

Multi-Area Throughput and Energy Optimization of UAV-aided Cellular Networks Powered by Solar Panels and Grid

Small Cells (SCs) mounted on top of Unmanned Aerial Vehicles (UAVs) can be used to boost the radio capacity in hotspot zones. However, UAV-SCs are subject to tight battery constraints, resulting in frequent recharges operated at the ground sites. To meet the UAV-SCs energy demanded to the ground sites, the operator leverages a set of Solar Panels (SPs) and grid connection. In this work, we demonstrate that both i) the level of throughput provided to a set of areas and ii) the amount of energy that is exchanged with the grid by the ground sites play a critical role in such UAV-aided cellular network. We then formulate the J-MATE model to jointly optimize the energy and throughput through revenue and cost components. In addition, we design the BBSR algorithm, which is able to retrieve a solution even for large problem instances. We evaluate J-MATE and BBSR over a realistic scenario composed of dozens of areas and multiple ground sites, showing that: i) both J-MATE and BBSR outperform previous approaches targeting either the throughput maximization or the energy minimization, and ii) the computation time and the memory occupation of BBSR are reduced up to five orders of magnitude compared to J-MATE.

Figure 6: Measurement of the UAV energy consumption in the rural area of Rotorua, New Zealand. The data recorded during the experiment was used to tune the parameters used in our model.

Researchers: Luca Chiaraviglio and Nicola Blefari Melazzi (Uniroma2), Fabio D'Andreagiovanni (CNRS, France), Jairo Gutierrez and William Liu (Auckland University of Technology, New Zealand), Mohamed Slim Alouini (KAUST, Saudi Arabia), Kim-Kwang Raymond Choo (University of Texas at San Antonio, USA).

Research and Innovation Projects

SMILE (Scalable Structured Micro-Illumination Light Engines)

The SMILE (Scalable Structured Micro-Illumination Light Engines) project has recently been accepted for funding in the 2019 H2020 FET-Proactive call. The goal of SMILE is to develop microLED platforms, giving access to a variety of novel applications. SMILE is based on an ongoing FET-Open project called ChipScope, which focuses on developing the first chip-sized optical microscope with super-resolution capabilities, using nanoLED arrays with individual pixel control. Contrary to the approach followed in ChipScope, where LEDs as small as possible are of main interest, SMILE is targeted towards larger microLEDs in larger arrays. This will allow much higher light intensities, but the larger dimensions also enable hybrid integration with CMOS microelectronics for individual pixel control. As a result, a fully scalable microLED platform will be developed in SMILE, with control over number of pixels, intensity, switching speed and large reduction of cost as soon as mass production becomes feasible. The microLEDs can also be combined with existing color converter technology, e.g. based on phosphors, resulting in flexibility in wavelength. Therefore, this technology could also be used for activating or controlling biological systems or chemical reactions, even with spatial control. During the project, which will last two years starting from December 2020, the the SMILE platform will be evaluated with the help of end users in the application fields of DNA chip fabrication, Maskless photolithography, Optogenetics, High-throughput fluorescence microscopy and Chip-based holographic microscopy.

Website: https://www.linkedin.com/company/smile-platform/
Researchers: M. Auf der Maur, K. Kluczyk, A. Di Carlo

H2020 – FLEXGAN: Ka-band GaN-based SSPA for flexible payloads and multicarrier operation for 5G satellite concept

FLEXGAN (Ka-band GaN-based SSPA for FLEXible payloads and multicarrier operation for 5G satellite concept) is a European research project co-funded from EU H2020 program funds. The project aims at designing, developing and testing, in a representative space environment (TRL5), a low cost high power and efficient Ka-band Gallium Nitride (GaN) Solid State Power Amplifier (SSPA) with RF output power varying capability (flexible SSPA), with high innovative & low loss recombination schemes and with the ability to operate in multicarrier operation mode for highly flexible payloads for 5G satellite applications. The operational frequency band is 17.3-20.2 GHz and the objective output power is 125 W CW. 5G demand requires the deployment of Very High Throughput Satellites (vHTS) than can satisfy the expected needs implying a growth opportunity for GEO satellites. This kind of spacecraft offers high capacity, large number of users and communication volumes (1 Terabit/s per satellite), with lower cost per GBPS, increasing the flexibility since the satellite capacity is allocated where it is needed. Future vHTS satellites will make use of Ka/Q/V gateways where the forward payload link will operate in K-band. Traditionally, demand for power at high frequencies has resulted in TWTAs as the logical amplifier of choice; this is due to the fact that traditional SSPA technology was unavailable at similar performance levels. However, technological advancements such as linearization, miniaturization, and the use of different materials such as GaN, have levelled the playing field for SSPAs. The objective of FLEXGAN is to design, develop and test in a representative space environment (TRL 5) a low-cost high-power and efficient Ka-band GaN SSPA with RF output power varying capability, with high innovative & low loss recombination schemes and able to operate in multicarrier operation mode for on-board 5G satellite applications. The main innovations that FLEXGAN brings are:

1. transfer known terrestrial technologies to space;
2. SSPA able to provide the required output power maximizing the power added efficiency to compensate the downlink fading losses;
3. SSPA able to transmit in multicarrier mode w/o memory effect;
4. Implementation of highly innovative linearization techniques;
5. use of lightweight composite structures to decrease the weight of the overall SSPA.

FLEXGAN will allow to reinforce and corroborate the use of GaN technology for space applications. The partners of the projects are:

- TTI (Prime, Spain)
- Airbus Defence & Space (France)
- Department of Electronic Engineering of University of Roma Tor Vergata – DIE (Italy)
- Tecnalia (Spain)
- OMMIC (France)

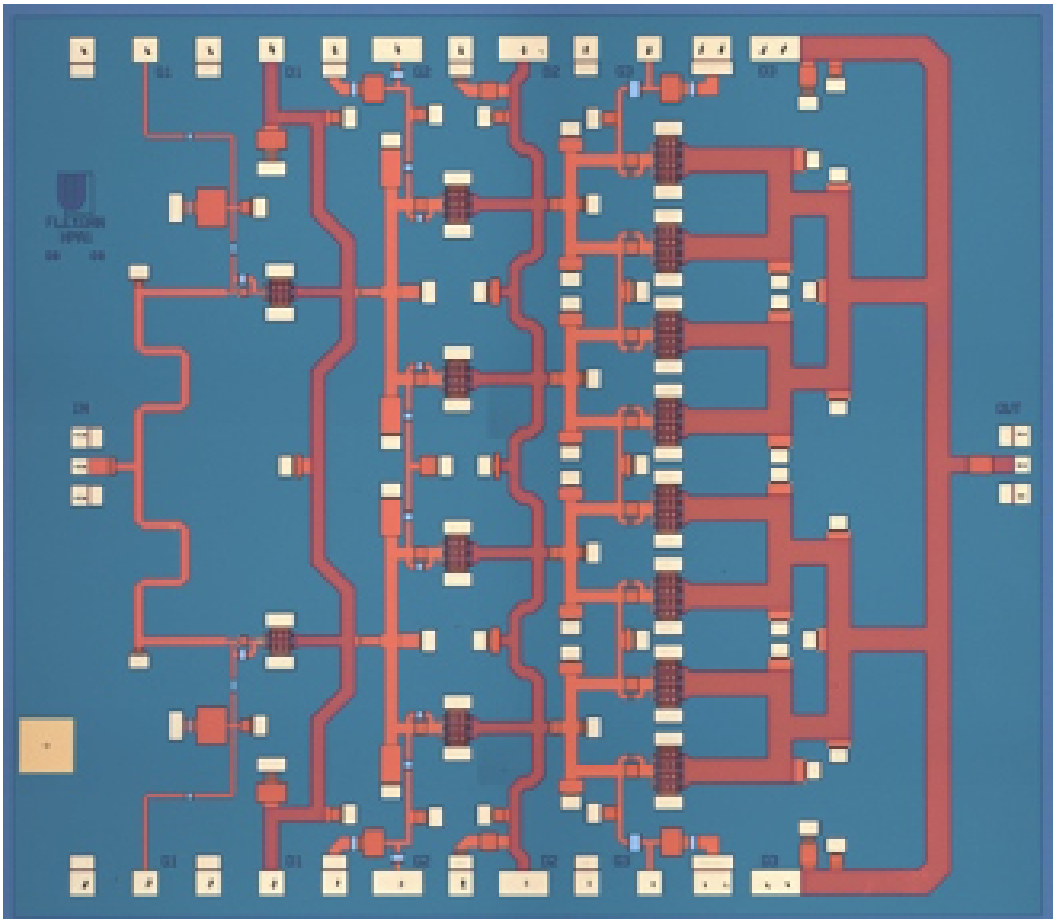

Figure 7: Realized 10W Ka band MMIC PA based on GaN technology (OMMIC D01GH process).

Website: http://h2020-flexgan.eu/
Researchers: Paolo Colantonio, Rocco Giofrè, Franco Di Paolo.

MiGaNSOS: Millimetre wave Gallium Nitride Space evaluation and application to Observation Satellites

MiGaNSOS (Millimetre wave Gallium Nitride Space evaluation and application to Observation Satellites) is a EU H2020 project investigating on technology and electronic circuits for space to enhance European competitiveness in this sector. This project is performed in cooperation with Thales Alenia Space (IT), VTT (FIN), and OMMIC (FRA), being respectively the system integrator, technology evaluator, and technology provider. Tor Vergata acts as Prime Contractor, design authority, and characterization & modeling group. MiGaNSOS projects is pursuing its activities to address the following objectives:

First Objective is to assess and space-evaluate a "state of the art" GaN/Si process for open foundry use, which will lead to new industrial products greatly influencing European companies' competitiveness. The process to be evaluated is the 100 nm GaN/Si technology developed by OMMIC; a preliminary evaluation will also be performed on the 60 nm GaN/Si process as being optimized by OMMIC as the natural extension for higher frequency applications. This objective shall be realised via the realisation of test vehicles dedicated to the evaluation process and basic monolithic functionalities such as Low Noise Amplifiers (LNAs), High Power Amplifiers (HPAs) and Single-Pole Double-Throw Switches (SPDT) and their Single-Chip integration (Single-Chip Front-End, SCFE) as demonstrators of the technology.

Second Objective consists in the demonstration of the simultaneous use of 100 nm and 60 nm GaN/Si technologies. This opens up the possibility to use them not only for the realization of the same wafer run but also within the same circuit, Such unique feature, unprecedented to date in available commercial foundry processes, represents a real technological breakthrough, increasing circuit design flexibility and resulting circuit performance.

Third objective of MiGaNSOS resides in the demonstration of future application of the developed technologies in advanced space equipment. In particular, a Ka Band Synthetic Aperture Radar (SAR) antenna shall be taken as reference and the fully integrated SCFE shall be integrated in a demonstrator replicating the basic building block of the Ka Band active antenna.

Finally, the fourth objective consists in disseminating the obtained results, making available the evaluated technology to the scientific and industrial communities and addressing new market opportunities.

Figure 8: MiGaNSOS project logo.

Website: http://migansos.eu/
Researchers: Patrick Longhi, Walter Ciccognani, Sergio Colangeli, Lorenzo Pace, Ferdinando Costanzo, Ernesto Limiti.

ULTRAWAVE: Ultra capacity wireless layer beyond 100 GHz based on millimeter wave Traveling Wave Tubes

ULTRAWAVE (Ultra capacity wireless layer beyond 100 GHz based on millimeter wave Traveling Wave Tubes)tThe ULTRAWAVE project is aimed at developing a high capacity backhaul that enables 5G cell densification by exploiting bands beyond 100 GHz. New travelling wave tubes delivering high power will allow the creation of an ultra capacity layer providing more than 100 Gbps per kilometer square in Point to Multi point at D-band (141 – 174.8 GHz) fed by novel G-band (300 GHz) Point to Point high capacity links. The ULTRAWAVE system is empowered by the convergence of three main technologies: vacuum electronics, solid-state electronics and photonics. This ULTRAWAVE layer will enable backhaul of hundreds of small and pico cells, no matter the density, opening scenarios for new network paradigms aiming at a full 5G implementation.

Traveling wave tubes amplifiers (TWT) Traveling Wave Tubes are the only devices able to provide power at Watt level in a multi-GHz band at millimetre waves. Two novel TWTs are to be designed and realized at the D- and G-bands, respectively, to enable the ULTRAWAVE ultra capacity layer. Technologies and process at the state of the art will be adopted. The TWTs are designed and fabricated at Lancaster University, UK, in collaboration with Goethe University of Frankfurt, Germany and HF Systems Engineering GmbH, Germany. The development of TWT operating at such high frequencies is a considerable challenge that requieres high precision alignment and fabrication of the electromagnetic structures, new cathodes enabling high current density, novel circuit designs having strong beam-wave interaction, high vacuum levels and nanoscale surface roughness of the metal walls to provide low loss.

New MMIC chipsets The D-Band (141 – 148.5 GHz) chipset is based on the new D004IH 40 nm process developed at OMMIC, France. The chipset includes the Low Noise Amplifier (LNA), the up-converter and the down-converter. The MMICs have been designed at University of Roma Tor Vergata, Italy. The power amplifier to drive the TWT and for the terminal has been designed and fabricated by Ferdinand Braun Institute (FBH), Germany using 0.8 μ m InP DHBT (double heterojunction bipolar transistor). The G-band chipset includes a power amplifier as driver for the TWT and a down converter, both to be designed and fabricated by FBH with an advanced process with a maximum frequency around 500 GHz. A LNA utilizing the OMMIC 40nm process has been designed by University of Rome Tor Vergata and realized at prototype level by OMMIC as first trial of an industrial process for G-band LNAs.

G-band photonic transmitter A G-band photonic transmitter for the Transmission Hub has been designed and fabricated by Universidad Politécnica de Valencia, Spain. Fiber optic technology for wireless systems offers extremely wide bandwidth which allows to transmit several channels in parallel while tuning the central frequency. The G-band transmitter is based on the heterodyne beat between two spectral lines in a unitravelling photodiodes (UTC-PD).

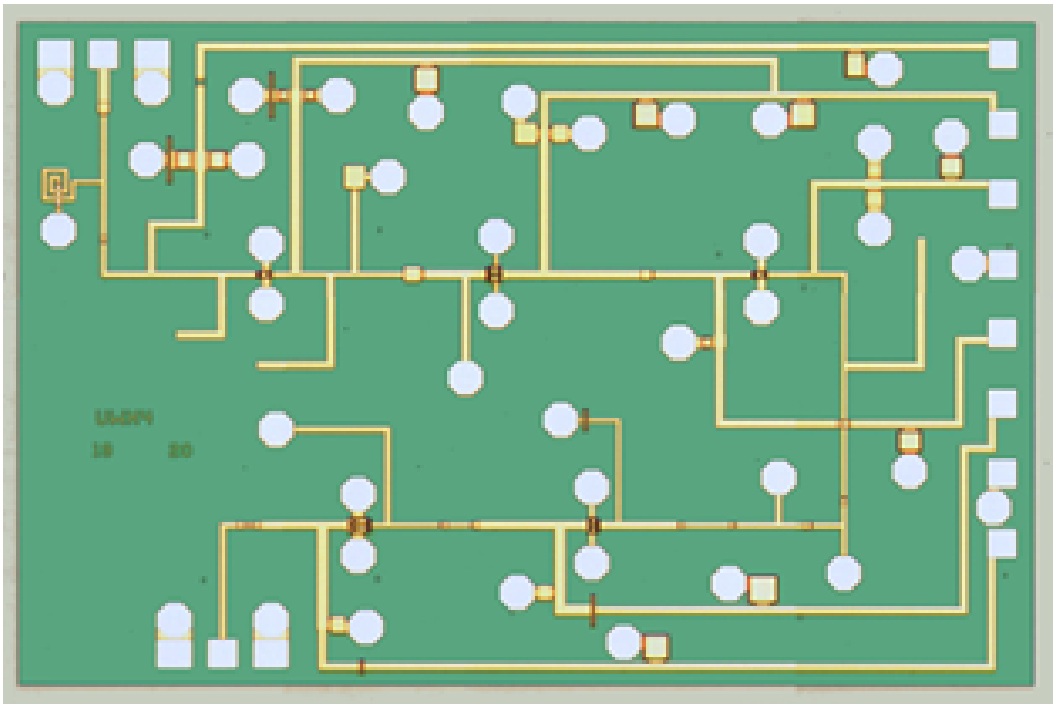

Figure 9: Microphoto of the times-4 frequency multiplier MMIC, with output frequency in the 92-96 GHz.

Website: http://ultrawave2020.eu/

Researchers: Sergio Colangeli, Walter Ciccognani, Lorenzo Pace, Riccardo Cleriti, Ernesto Limiti.

High Power Amplifiers Technology H2020-ESA-009

ESA has defined a roadmap for the evolution of GNSS systems which focuses on the evolution of GALILEO (namely GALILEO 2nd Generation or G2G in short). The potential evolution of GALILEO are organised into several evolution categories depending on the maturity level. At navigation payload level, more demanding requirement s in terms of output power, flexibility and efficiency are considered. Flexibility at HPA level is defined as technology allowing change of RF output power by commanding variation of the bias operating point within a limited range, maintaining constant efficiency. The increase in EIRP requires increased output power from the amplifiers, which in turn requires the consideration of new technologies. Solid State Power Amplifiers (SSPA) based on Gallium Nitride (GaN) are potential candidates. The aim of this project is to realize an SSPA for L-band applications, targeting an output power level of 150W by using GaN-on-SiC devices developed by UMS (France foundry). The partners of this projects are:

- TTI (Prime, Spain);
- OHB (Germany);
- Department of Electronic Engineering of University of Roma Tor Vergata – DIE (Italy).

The role of DIE researchers involved in this project is the development of the Radio Frequency Tray (RFT), i.e., the realization of the RF chain for the amplification and signal conditioning.

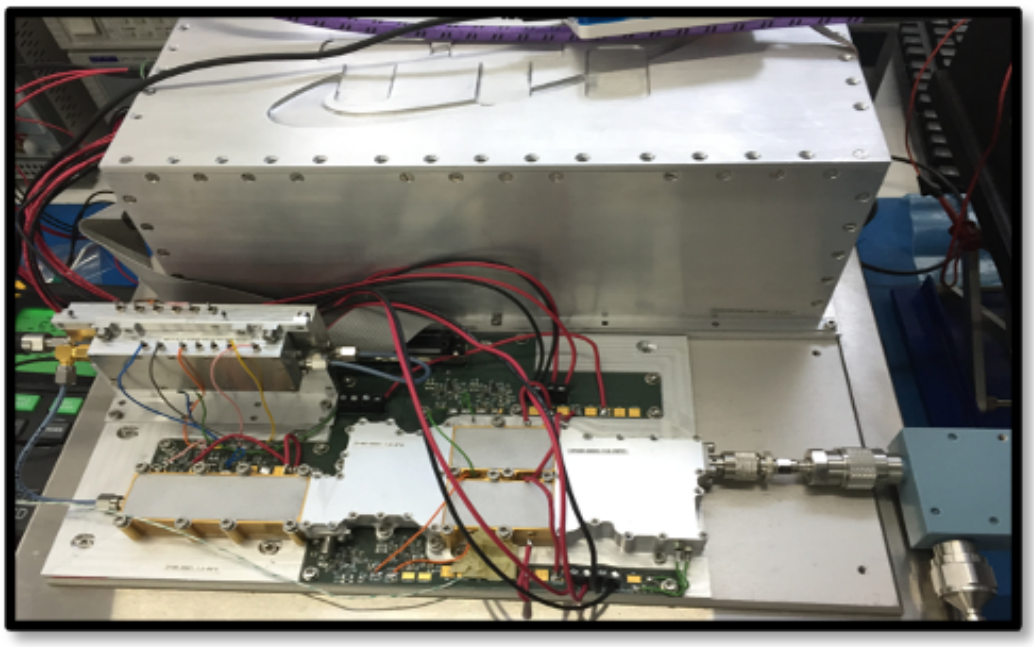

Figure 10: Breadboard model of the RF Tray under test campaign.

Website: https://h2020nav.esa.int/project/h2020-009
Researchers: Paolo Colantonio, Rocco Giofrè.

Secure Hybrid In-Network caching Environment over satellite systems

Satellite systems can result beneficial in the caching operations (i.e. CDN) thanks the intrinsic broadcasting capability over large areas. In this framework, the most challenging, but at the same time attractive, breakthrough is the multicast in multibeam satellite systems, which brings a high flexibility in the service configuration taking into account a regional granularity for content distribution. We are working on the deployment and integration of a multicast satellite component with a pool of Network Coding (NC) servers, which can further improve on performance with the aggregation of multiple flows into a lighter coded flow with the aim of saving available bandwidth. In general, NC multimedia servers can be installed in re-seller's premises, while interconnected at the network level to the multi-gateway interconnection ring in order to forward traffic to one or more satellite gateways (GW) leveraging standard IP methods for multicast group management and multicast routing. Potential multicast users are virtual caches behind Satellite Terminals (STs). In the network architecture proposed in Figure 1, a "core" multicast router, also called "rendezvous point", collects all the membership requests, forwards them to the appropriate NC-server (multicast source) and keeps updating the multicast routing table. Each and every NC-server with a least one active membership forwards data to the core multicast router, which in turn leverages the mutlicast routing table to distribute data to GWs with at least one active multicast member. Depending on its internal routing table, each GW encapsulates and multicasts the data on one or more served beams. In case of a regional service, a single beam could be sufficient to multicast content towards caching-enabled terminals. Specifically, the basic paradigm aims to improve the aggregate network efficiency instead of the optimization on the local cache hits. The local caching is tailored to minimize the overall data exchanged in the air when serving a number of multimedia content requests. This approach provides its advantages when content requests are unpredictable (content popularity is not easily applicable), like with large scale services with generic streaming capabilities (i.e., YouTube) and with an increasing number of requesters. However, the additional flexibility in the proposed satellite multi-beam configuration allows to complement such a basic system with a popularity-driven distribution accounting for either regional-based or service-based popularity. The above-mentioned reflections about popularity, combined with the announced possibility of leveraging multibeam satellite communications, have motivated us in further exploring the use of satellite caching as a novel content-aware infrastructure.

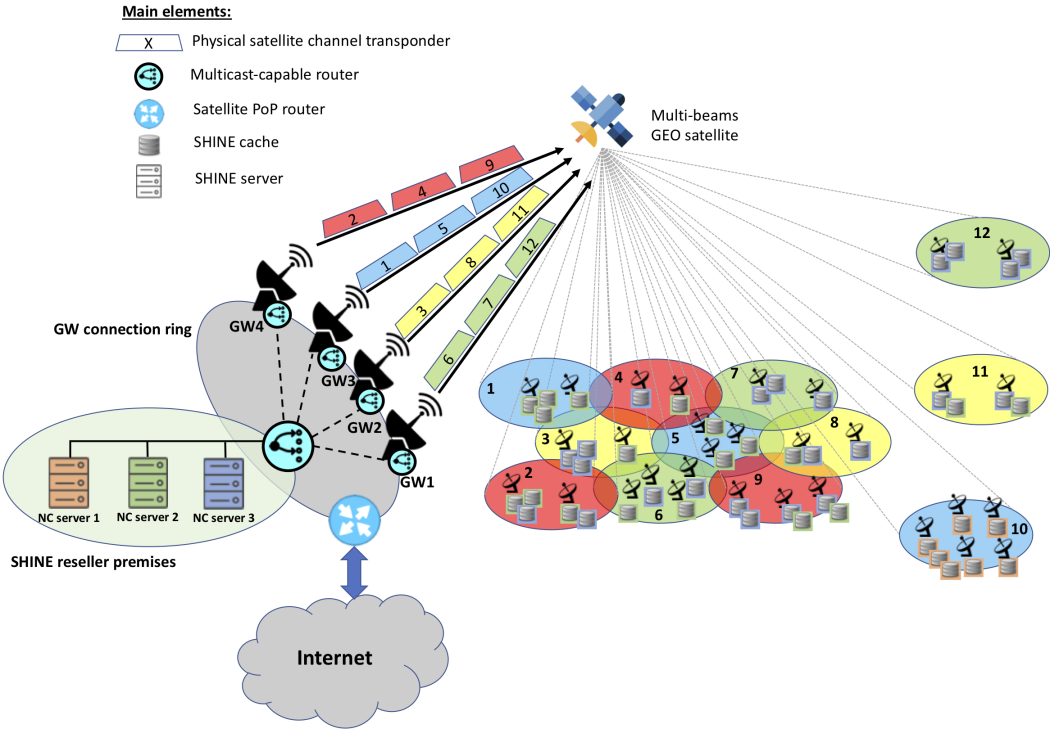

Figure 11: Satellite multi-beam SHINE architecture.

Website: https://www.tlcsat.it/shine/
Researchers: M. Luglio, C. Roseti, F. Zampognaro.

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 Master's 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 Master's 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.

Bachelor's Degree and Master's Degree in Electronics Engineering

It is one of the most memorable courses in Italy. It is organized in a three-year Bachelor's Degree and a two-year Master's Degree. The task of the Bachelor's 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 Master's 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 Master's 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 student's 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

Bachelor's Degree and Master's 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 Bachelor's Degree in Internet Engineering and the English taught Master's 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 Bachelor's Degree offers three research programmes (Internet of Things, CyberSecurity, Communication Technologies); the Master's 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

Upcoming Events

- **Event:** 2021 IEEE Aerospace Conference, 6 - 13 March 2021.
  Venue: Virtual Conference.
- **Event:** 2021 15th European Conference on Antennas and Propagation (EuCAP), 22 - 26 March 2021.
  Venue: Dusseldorf, Germany
- **Event:** 2021 IEEE International Conference on Pervasive Computing and Communications (PerCom), 22 - 26 March 2021.
  Venue: Virtual Conference.
- **Event:** 2021 IEEE Wireless Communications and Networking Conference (WCNC), 29 March - 1 April 2021.
  Venue: Nanjing, China.
- **Event:** 2021 IEEE Asia Pacific Conference on Wireless and Mobile (APWiMob), 8 - 10 April 2021.
  Venue: Bandung, Indonesia.
- **Event:** 2021 International Symposium on Electrical and Electronics Engineering (ISEE), 15 - 16 April 2021.
  Venue: Ho Chi Minh, Vietnam.
- **Event:** 2021 IEEE 18th International Symposium on Biomedical Imaging (ISBI), 13 - 16 April 2021.
  Venue: Virtual Conference.
- **Event:** 2021 IEEE 93rd Vehicular Technology Conference (VTC2021-Spring), 25 - 28 April 2021.
  Venue: Helsinki, Finland.
- **Event:** 2021 European Wireless (EW), 5 - 7 May 2021.
  Venue: Verona, Italy.
- **Event:** 2021 IEEE Radar Conference (RadarConf21), 7 - 14 May 2021.
  Venue: Virtual Conference.
- The cluster of EU projects Beyond 5G is organizing the third edition of the “Towards THz Communications” workshop to be held online on Friday 12 March 2021.

Achievements

- The work "Will the Proliferation of 5G Base Stations Increase the Radio-Frequency Pollution?" by Luca Chiaraviglio, Giuseppe Bianchi and Nicola Blefari Melazzi (Uniroma2), Marco Fiore (IMDEA Networks, Spain) has received the Best Paper Award at the 91st edition of the IEEE Vehicular Technology Conference (VTC-Spring 2020). The paper has been ranked 1st out of 550 papers accepted at the conference.
- "Best Paper Award" for "Development of a V-Band MMIC chip-set for in-orbit Inter-Satellite Links" by Pace, L., Longhi, P.E., Fenu, S., Ciccognani, W., Colangeli, S., Limiti, E., International Symposium on Advanced Electrical and Communication Technologies, ISAECT 2019.
- Second place of the "Best Student Paper Award" for "A Times-4 Frequency Multiplier from K- to W-band", 2019 PhotonIcs Electromagnetics Research Symposium - Spring, Subcommittee 4 (Antennas and Microwave Technologies), Pace, L., Longhi, P.E., Fenu, S., Ciccognani, W., Colangeli, S., Limiti, E.

Recent Publications

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[Ali+20a] A. Ali et al. "168-195 GHz Power Amplifier With Output Power Larger Than 18 dBm in BiCMOS Technology". In: *IEEE Access* 8 (2020), pp. 79299–79309.

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