

**EU  
CNC** 2018  
June 18-21  
Ljubljana, Slovenia

# 5G AND BEYOND

**FINAL PROGRAMME**



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# GREETINGS FROM THE GENERAL CO-CHAIRS

## Welcome to 5G and Beyond



It is our great pleasure to welcome you to the European Conference on Networks and Communications (EuCNC 2018), the 27th edition in the series. We are convinced that, once again, this conference will be a worthwhile and memorable experience.

This year, EuCNC is coming to Slovenia, home of the fastest growing digital society in the EU, a boutique country, which has been unifying its strengths into becoming a green reference country on the path towards the Gigabit society. The importance of 5G in digital transformation has been recognised in Slovenia on the governmental and regulatory levels through several national and cross-border initiatives, which established grounds to kick-start 5G piloting projects in multiple vertical sectors, including public safety and automotive industry. The mission is backed up with ambitious plans for broadband development until 2020 affording a hundred megabit speed for all, and an already adopted Information Security Act that places Slovenia among the leading EU countries on the cyber security map.



The host city, Ljubljana, is one of the most sustainable destinations in the World and proudly holds the title of the European Green Capital. Being a city of culture and arts, it is home to numerous theatres, museums and galleries, and boasts one of the oldest philharmonic orchestras in the World. Ljubljana is also high on the list of European capitals of science and innovation. With numerous research and scientific institutions, Ljubljana is home to more than 50.000 students

and boasts a remarkable rise of entrepreneurship and high-tech companies in the recent past, which altogether gives the place a special young and creative vibe.

This is what makes Ljubljana a great environment to discuss connectivity platforms and networks, which are at the heart of digital transformation from both the economic and societal perspectives. They underpin the development of numerous societal applications such as connected cars, smart manufacturing, smart energy grids, or personalised healthcare, which will also enable the next generation of the “app economy” leveraging the full power of the IoT and the data value chain. In line with Europe’s Gigabit society targets for 2025, 5G is expected to be an essential enabler for the next big step in digital transformation by providing connectivity to people, wherever they live, work, gather or travel. It is also expected to transform the economy by providing wireless connectivity to all objects, in line with our Strategy for Digitising European Industry.

We are entering into a critical phase in the global race to 5G. EuCNC 2018 is an excellent occasion to demonstrate that Europe is moving quickly towards large-scale trials and deployment initiatives, to create favourable conditions for the creation of the 5G ecosystem – including verticals – and to prepare for its market introduction. At the same time and in view of Europe’s next framework research and innovation programme, EuCNC provides the right forum for research discussions beyond 5G, as the connectivity landscape is expected to evolve dramatically in the next decade. The years 2020 to 2030 will witness world-wide competition on mastering evolving 5G technologies and beyond 5G, thus they represent a decisive field of new research and innovation and market opportunities.

In order to maintain and reinforce Europe’s position in network and service infrastructures while enabling a human-centric Internet, the Commission has launched the Next Generation Internet (NGI) initiative, which can meet the new and more diverse needs of European citizens and businesses in a secure and trusted way, integrating technological game changers such as Distributed Ledger Technologies, Artificial Intelligence, or interactive and immersive technologies. The theme for EuCNC 2018 “5G and Beyond” reflects well the EU’s 5G research/deployment roadmap as well as the future development of smart network connectivity technologies in Europe, in the context of NGI and in relation to all global initiatives in the field.

The event starts with a pre-conference day hosting eight workshops and three tutorials. From Tuesday onward, attendees are welcome to enjoy four exciting keynotes, three panel sessions addressing the current hot topics in 5G and a broad choice of regular and special sessions organised in six parallel technical tracks. Also, the event will host an exciting exhibition of latest advances in 5G and beyond.

When here for the event, guests will have a unique chance to enjoy Ljubljana’s warm and lively summer evenings on its vibrant riverbanks and explore cultural and culinary gems of Slovenia. We wish you an enjoyable and memorable EuCNC 2018. Welcome to Ljubljana!

**Pearse O’Donohue and Bojan Križ**  
*Conference General Co-Chairs*

Ljubljana, Slovenia







# WELCOME NOTE FROM THE TECHNICAL PROGRAMME COMMITTEE CO-CHAIRS

## EuCNC 2018, welcome to Ljubljana!



It is not a coincidence that we meet in Ljubljana this year! One of the greenest and most liveable capitals, Ljubljana has secured its spot on the map of Europe's places where science, innovation and entrepreneurship go hand in hand with green and sustainable living and a high quality of life. As a young country of opportunities, it offers an ideal backdrop to discuss what the digital future holds for us and how 5G will reach beyond to create smart, sustainable and most of all liveable future for us all.



Over the years, EuCNC has grown into a truly global event that brings together cutting-edge research, world-renown industries as well as representatives of the SME arena. With this mix it creates a unique opportunity to host in one place the latest scientific discoveries, deployment advancements and lessons learned from practice, and opens the door for new business opportunities and partnerships.

This year's edition is about 5G in vertical industries, experimentation in real world and results and lessons learned from first 5G deployments. European H2020 5G PPP Phase 1 and Phase 2 projects' results will be showcased and the event will facilitate discussions about opportunities to leverage on recent 5G advancements in order to support the rollout of 5G in various verticals, such as smart cities, automotive, public protection and disaster relief, smart mobility, digital health, and more. But there's more; themed 5G and Beyond, this year's edition is promising to

give some insights to exciting challenges coming up after the 5G rollout.

The Deputy Prime Minister and Minister for Public Administration will give an opening talk, as well as the Director General of the Information Society Directorate of Slovenia, and the EC's Director for the Future Networks Directorate of DG CONNECT. Guests will have the opportunity to enjoy exciting keynote talks given by leading experts in the field, and immerse in lively panel discussions around the currently hot topics in 5G and beyond. A variety of workshops, tutorials and technical sessions are available to choose from and the event will again host a large exhibition demonstrating latest prototypes developed by the European 5G projects, which by now became a trademark of the event.

To make EuCNC 2018 a truly unique and memorable experience, a colourful choice of social activities is accompanying the official programme. Take the opportunity to relax and meet old and new friends over a glass of Slovenian wine at the welcome reception, and join us for the gala dinner, a highlight of the social programme hosted in the magnificent Art Nouveau reception hall that will take you on an unforgettable journey through Slovenian fine dining and music. And this is where it only begins! In Ljubljana everything is a stone's throw away and we invite you to enjoy its summer vibe on the riverbanks boasting a collection of intricately crafted bridges, luscious urban gardens and numerous historic, gastronomic and cultural attractions. And for the adventurous souls, with a bit of planning, you can enjoy the snowy slopes of Alps in the morning followed by a dip into the Mediterranean Sea in the afternoon!

Dear guests, welcome to EuCNC 2018 – and welcome to Slovenia, the only country in the world with the word love in its name!

**Mojca Volk and Mihael Mohorčič,**  
*EuCNC 2018 Co-hosts and TPC Co-chairs*

# CONFERENCE PROGRAMME OVERVIEW

## MONDAY, JUNE 18 2018 - WORKSHOPS AND TUTORIALS

08:00 - 18:00	REGISTRATION <i>Foyer 2</i>						
09:00 - 10:30	<b>WS1:</b> Workshop on Vertical Industries & Services for 5G (VIS5G)  <i>Štih hall</i>	<b>WS2:</b> From cloud ready to cloud native transformation: What it means and Why it matters  <i>E1 hall</i>	<b>WS3:</b> Multi-provider, multi-vendor, multi-player orchestration: from distributed cloud to edge and fog environments in 5G  <i>M3 hall</i>	<b>WS5:</b> Optical and Wireless Network Convergence: An enabler for 5G  <i>E2 hall</i>	<b>WS7:</b> 3rd Network Management and QoS for 5G Networks  <i>E3 hall</i>	<b>TUT1:</b> Wireless radio access for 5G and beyond  <i>E4 hall</i>	<b>TUT3:</b> Wireless community networks and 5G: the 7-Billion-user challenge  <i>M4 hall</i>
10:30 - 11:00	COFFEE BREAK <i>Foyer 1</i>						
11:00 - 13:00	<b>WS1</b> (cont.)	<b>WS2</b> (cont.)	<b>WS3</b> (cont.)	<b>WS5</b> (cont.)	<b>WS7</b> (cont.)	<b>TUT1</b> (cont.)	<b>TUT3</b> (cont.)
13:00 - 14:00	LUNCH <i>Foyer 1</i>						
14:00 - 15:30	<b>WS1</b> (cont.)	<b>WS6:</b> 5th International Workshop on programmable networks: Demystifying software networks for Vertical Industries  <i>E1 hall</i>	<b>WS3</b> (cont.)	<b>WS5</b> (cont.)	<b>WS8:</b> Next generation network systems security  <i>E3 hall</i>	<b>TUT2:</b> Vertical-oriented end-to-end orchestration in 5G networks: modelling, optimization, implementation, and verification  <i>E4 hall</i>	<b>WS4:</b> 2nd Workshop on business models and techno-economic analysis for 5G networks  <i>M4 hall</i>
15:30 - 16:00	COFFEE BREAK <i>Foyer 1</i>						
16:00 - 18:00	<b>WS1</b> (cont.)	<b>WS6</b> (cont.)	<b>WS3</b> (cont.)	<b>WS5</b> (cont.)	<b>WS8</b> (cont.)	<b>TUT2</b> (cont.)	<b>WS4</b> (cont.)

## TUESDAY, JUNE 19

08:00 - 18:00	REGISTRATION <i>Foyer 2</i>					
09:00 - 11:00	<b>OPENING SESSION</b> <b>KEYNOTE 1</b> - Michele Zarri (GSMA) <b>KEYNOTE 2</b> - Thomas Kuerner (Braunschweig University of Technology) <i>Linhart hall</i>					
11:00 - 11:30	EXHIBITION OPENING & COFFEE BREAK <i>Foyer 1</i>					
11:30 - 13:00	PHY1: New coding and modulation schemes  <i>E1 hall</i>	NET1: Network slicing  <i>E2 hall</i>	RAS1: Radio resource management and cell planning  <i>E3 hall</i>	WOS1: Wireless and Optical Backhaul  <i>E4 hall</i>	SPS11: Unlocking the 5G potential for smart energy grids  <i>Štih hall</i>	SPS12: Wireless network research: think outside the box  <i>Linhart hall</i>
13:00 - 14:00	LUNCH <i>Foyer 1</i>					
14:00 - 14:30	POSTER SESSION 1 <i>Foyer 2</i>					
14:30 - 16:00	<b>PANEL 1</b> - 5G for Verticals: Evolving Requirements, deployment challenges and Business Cases <i>Linhart hall</i>					
16:00 - 16:30	COFFEE BREAK <i>Foyer 1</i>					
16:30 - 18:00	PHY2: Advanced and massive MIMO systems  <i>E1 hall</i>	NET2: Network function virtualization and orchestration  <i>E2 hall</i>	RAS2: Radio access performance optimization  <i>E3 hall</i>	WOS2: Latency and reliability in wireless networks  <i>E4 hall</i>	SPS9: Critical communications and public safety - National and EU Perspectives  <i>Štih hall</i>	SPS1: 5G-PPP Phase 3 introduction & ICT-19-2018 info- session  <i>Linhart hall</i>
18:00 - 20:00	WELCOME RECEPTION <i>Foyer 1</i>					



## WEDNESDAY, JUNE 20

08:00 - 18:00	REGISTRATION Foyer 2					
09:00 - 10:30	<b>KEYNOTE 3</b> - Walter Weigel (Huawei) <b>KEYNOTE 4</b> - Biswanath Mukherjee (University of California Davis) Linhart hall					
10:30 - 11:00	COFFEE BREAK Foyer 1					
11:00 - 12:30	<b>PHY3:</b> Millimeter-wave communications and antenna arrays E1 hall	<b>NET3:</b> Network slicing management E2 hall	<b>SPS8:</b> Spectrum issues, from Cognitive Radio to Spectrum sharing E3 hall	<b>SPS7:</b> Satellite solutions for the 5G network of networks E4 hall	<b>APP1:</b> Key technologies for application areas Štih hall	<b>OPE1:</b> Testbeds, pilots and DevOps Linhart hall
12:30 - 13:30	LUNCH Foyer 1					
13:30 - 14:00	POSTER SESSION 2 Foyer 2					
14:00 - 15:30	<b>PANEL 2</b> - Network Slicing: Real-world Opportunities with Open Standards and Open Source Linhart hall					
15:30 - 16:00	COFFEE BREAK Foyer 1					
16:00 - 17:30	<b>SPS3:</b> Terabit Wireless Transport for Networks Beyond 5G E1 hall	<b>NET4:</b> Fog, edge and cloud computing E2 hall	<b>SPS4a:</b> Resource Elasticity for 5G Network Architecture E3 hall	<b>WOS3:</b> Overlay and IoT networks E4 hall	<b>APP2:</b> 5G vertical application areas Štih hall	<b>OPE2:</b> Trials and experimentation Linhart hall
19:00 - 23:00	GALA DINNER Grand Hotel Union					

## THURSDAY, JUNE 21

08:00 - 14:30	REGISTRATION Foyer 2					
09:00 - 10:30	<b>PHY4:</b> Reconfigurable radios and Hardware/Software implementation E1 hall	<b>SPS5:</b> 5G Architecture towards Verticals E2 hall	<b>SPS4b:</b> 5G Mobile Network Architecture and New Radio Advances E3 hall	<b>SPS2:</b> COST spotlight – COST Actions on Networks and Communication E4 hall	<b>SPS6:</b> Reality check for Connected Autonomous Driving Štih hall	<b>SPS10:</b> Small Cells Deployment, Network Functions Virtualisation and Cloud Computing as “Enablers” of Innovative 5G Services Linhart hall
10:30 - 11:00	COFFEE BREAK Foyer 1					
11:00 - 12:30	<b>PANEL 3</b> - Smart connectivity in the context of Next Generation Internet Linhart hall					
12:30 - 13:30	CLOSING SESSION Linhart hall					
13:30 - 14:30	LUNCH Foyer 1					

# USEFUL INFORMATION

## EuCNC 2018 VENUE

### Cultural and Congress Centre Cankarjev Dom

Prešernova cesta 10

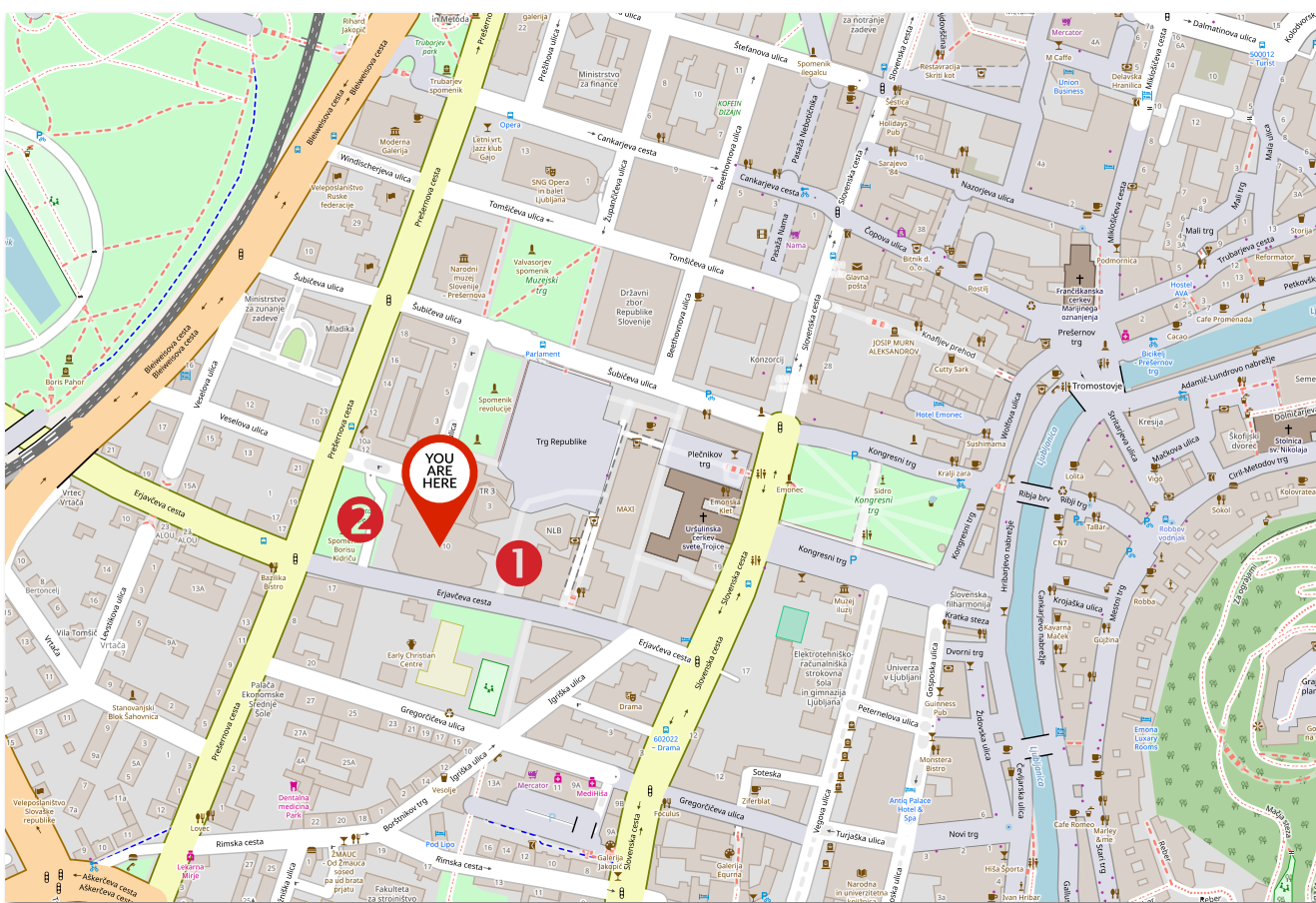
SI-1000 Ljubljana

Slovenia

46.049823N, 14.499124E

### Entrances for EuCNC attendees are

- 1 from Trg republike from the city centre direction (pedestrian access only)
- 2 from Prešernova street (main entrance, access also by car and public transportation)



## EuCNC 2018 REGISTRATION AND INFO DESK

is located in Foyer 2 (Level -2).

Opening times:

Monday June 18	8:00 – 18:00
Tuesday June 19	8:00 – 18:00
Wednesday June 20	8:00 – 18:00
Thursday June 21	8:00 – 14:30





Cankarjev dom, Linhart Hall, photo Brane Žalar



Cankarjev dom



## Social Media

### Stay tuned!

Follow us on social media and be the first to hear the latest on news, exciting happenings and updates!

Facebook    EuCNC

Twitter      @eucnc, @NetTechEU

LinkedIn     EuCNC (group)

### Official hashtag #EuCNC2018

Instagram    eucnc2018

Share your own stories and photos!

Include our official hashtag #EuCNC2018

Watch our live video stream on the conference website: [www.eucnc.eu](http://www.eucnc.eu)

or through EuCNC Virtual Congress app.

## EuCNC Virtual Congress app

Use the official conference app at EuCNC 2018 to plan your activities get connected!

- Navigate the event & create your personal agenda
- Tune in to a live stream from the big stage
- See who is attending and browse through the speakers & exhibitors list, and get connected via chat
- Vote for the Best EuCNC 2018 Booth Award & let us know what you think about the event

EuCNC Virtual Congress app in a web browser: [eucnc.mtv.si](http://eucnc.mtv.si)

iOS and Android mobile apps: <https://www.eucnc.eu/app/>

# OPENING SESSION

## Opening Addresses by:

### **Mojca Volk**

*EuCNC 2018 Co-host and  
TPC Co-chair*



Mojca Volk, Ph.D., is a Strategic Partnerships Manager at the Laboratory for Telecommunications (University of Ljubljana, Faculty of Electrical Engineering). She received her Ph.D. degree from University of Ljubljana in 2010 and is habilitated as assistant professor at University of Ljubljana - Faculty of Electrical Engineering. Her main areas of work are related to specialised 5G vertical sectors, including infrastructures and services for public protection and disaster relief and digital health solutions in clinical and consumer environments. Dr. Volk has considerable managerial and research experience in large international projects, including EU project management and international partnership cooperation in FP7 and H2020 programmes. She has been a steering board member in EU projects FI-STAR (FP7) and UNCAP (H2020) on the topic of digital health, and PPDR EU projects GEN6 (CIP), ARCADIA (H2020) and NEXES (H2020). She co-authored several books and more than 50 peer-reviewed journal and conference papers. Since 2014 she is actively involved also in the start-up arena with a current focus on advanced 5G quality and performance measurements and benchmarking.

### **Mihael Mohorčič**

*EuCNC 2018 Co-host and  
TPC Co-chair*



Mihael Mohorčič received B.Sc. (1994), M.Sc. (1998) and Dr.Sc. (2002) degrees in Electrical Engineering from the University of Ljubljana, Slovenia and M.Phil. (1998) degree in Electrical Engineering from the University of Bradford, UK. Currently he is a scientific councillor and head of the Department of Communication Systems at the Jožef Stefan Institute, and an associate professor in telecommunications at the Jožef Stefan International Postgraduate School. His main research areas include resource management and protocol design and optimization in terrestrial, stratospheric and satellite wireless networks. His current research topics are cognitive radio networks, cross-layer protocol design and optimisation, wireless sensor networks, M2M/IoT, dynamic composition of communication services and wireless experimental testbeds. He co-authored three books published by John Wiley & Sons, 9 book chapters and more than 180 peer-reviewed journal and conference papers. He actively participated in more than 20 Framework Programme projects since FP4, several COST Actions and national basic and applied projects, also having the role of project, work package and task leader, and being member of the Management, Steering and Scientific boards. He is currently contributing to H2020 projects eWINE, Fed4FIRE+, DEFENDER, NRG-5 and SAAM. He is a senior member of IEEE.

## **Boris Koprivnikar**

*Deputy Prime Minister and Minister  
of Public Administration of the  
Republic of Slovenia*



Mr Boris Koprivnikar is the Deputy Prime Minister and Minister of Public Administration of the Republic of Slovenia. In 1991, he received an Honours degree from the Faculty for Organizational Sciences at the University of Maribor where he specialised in Business Informatics Systems. In his previous position, as the Chairman of the Board of Social Institutions Association of Slovenia, he managed a public institution with a complex organizational scheme of 99 providers with over 10,000 employees providing services to more than 21,000 users within the public sector. In his work, he manages activities which are, to a great extent, an integral part of the Centre of the Government and focus on digital transformation of public administration as well as the economy and society as a whole. As Chief Digital Officer, he is actively promoting an ambitious initiative of Slovenia to become “a green reference country in digital Europe”. He aspires to bring together interests of the State, economy, and citizens for setting up a digital eco-system. He advocates the use of big data as one of the key resources for efficient management of public systems and development of new economic and business models. As a member of the ITU/UNESCO Broadband Commission for Sustainable Development he advocates for the vital role of broadband networks to accelerate progress of our society. Mr Boris Koprivnikar cooperates closely with the European Commission, the OECD and ITU and frequently gives lectures at national and international events, particularly in modernisation of public administration.

## **Pearse O'Donohue**

*Director for the Future Networks, DG  
CONNECT, EC & Conference General  
Co-Chair*



Pearse O'Donohue is Director for the Future Networks Directorate of DG CONNECT at the European Commission, dealing with policy development and research supporting the Digital Single Market as regards 5G networks, IoT, cloud and data flows and conceptualising new and innovative approaches towards service platforms and next generation Internet. Before becoming Director, Pearse was Head of the Cloud and Software Unit in DG CONNECT, dealing with the strategic development and implementation of policy on cloud computing and software. Until October 2014, Pearse was Deputy Head of Cabinet of Vice-President Neelie Kroes, previous European Commissioner for the Digital Agenda. He was responsible for advising the Vice-President on the development and implementation of policy on electronic communications, networks and services, as well as broadband, spectrum and other related policies such as Internet governance. Before that, Pearse was Head of the Radio Spectrum Policy Unit in the European Commission, DG CONNECT. Prior to joining the European Commission, Pearse held posts in the Irish Department of Foreign Affairs, the Permanent Representation of Ireland to the EU in Brussels, and as Assistant Director of the Brussels office of the Irish Business & Employers' Confederation.





## **Bojan Križ**

*Director General of the Information Society Directorate at the Ministry of Public Administration of the Republic of Slovenia & Conference General Co-Chair*



Bojan Križ is Director General of the Information Society Directorate at the Ministry of Public Administration of the Republic of Slovenia. He studied at the Faculty of Electrical Engineering, University of Ljubljana, Slovenia, and received his Master of Science in Telecommunications. Between 2001 and 2017 he was working in Iskratel, leading European provider of communications solutions. He worked on the development of Siemens EWSD systems and the integration and automation testing processes to fasten “time2market”. In 2007, he continued his career within product management and heading complex ICT projects for internationally renowned companies and Telco operators, focusing on turnkey solutions. He was entrusted with several leading positions in the management of products and production. He continued his career as the coordinator for the standard bodies 3GPP and ETSI. As Deputy Director for Multimedia core networks, he focused his career in the field of multimedia solution strategy for Telco operators and medium-sized enterprises. At the end of May 2017, he joined the team at the Ministry of Public Administration, in the position of act. Director General for the Information Society in Slovenia. On 18 October 2017, the Government of the Republic of Slovenia appointed him as Director-General of the Information Society Directorate in the Ministry of Public Administration for 5 years.



# KEYNOTE SPEAKERS

## Business model-driven 5G deployment

### Michele Zarri

Technical Director, GSM Association,  
United Kingdom



Tuesday, 19 June, 9:00-10:30, Room Linhart hall

The presentation will cover the following:

- Who is GSMA?
- The role and objectives of GSMA in the 5G era
- An evolving technology enabling revolutionary business models
- Alternatives for introduction of 5G

*Michele Zarri is a technical director in GSMA where he works on advanced technologies and 5G. Michele graduated in telecommunications engineering at University of Pisa (Italy) and completed his studies at King's College of London (UK). Prior joining the GSMA Michele worked for Deutsche Telekom where he accrued more than 15 years of experience in standardization of mobile technologies. Michele served as chairman of working groups both in 3GPP and GSMA.*

## THz Communications – An Option for Wireless Networks beyond 5G?

### Thomas Kürner

University Professor,  
Braunschweig University of Technology



Tuesday, 19 June, 9:00-10:30, Room Linhart hall

Already a couple of years ago THz communications have not only become an attractive new research area on channel modeling but also triggered a couple of projects heading to develop appropriate technological solutions to enable the set-up of hardware demonstrators. In parallel discussions and activities in standardization and regulation already took off. In October 2017, IEEE published Std. IEEE 802.15.3d-2017 the worldwide first wireless communications standard operating in the 300 GHz frequency band. In parallel to the standardization process activities at the ITU-R level targeting on the provision of an appropriate regulatory framework at the World Radio Conference 2019 (WRC-2019) via a dedicated agenda item have taken off. The speaker has been actively involved in all those areas. The talk will provide a brief overview on the current status of the development of THz Communication systems focusing on the past and current activities at IEEE 802 and the WRC 2019 preparations as well as on recent results on advanced channel characterization at 300 GHz and hardware demonstrators operating in this frequency range.

*Thomas Kürner received his Dipl.-Ing. degree in Electrical Engineering in 1990, and his Dr.-Ing. degree in 1993, both from University of Karlsruhe (Germany). From 1990 to 1994 he was with the Institut für Höchstfrequenztechnik und Elektronik (IHE) at the University of Karlsruhe working on wave propagation modelling, radio channel characterisation and radio network planning. From 1994 to 2003, he was with the radio network planning department at the headquarters of the GSM 1800 and UMTS operator E-Plus Mobilfunk GmbH & Co KG, Düsseldorf, where he was team manager radio network planning support responsible for radio network planning tools, algorithms, processes and parameters from 1999 to 2003. Since 2003 he is Full University Professor for Mobile Radio Systems at the Technische Universität Braunschweig. His working areas are indoor channel characterisation and system simulations for high-speed short-range systems including future terahertz communication system, propagation, traffic and mobility models for automatic planning and self-organization of mobile radio networks and vehicle-to-X communications.*



## 5G applied to vertical industry use cases-Car, Health, and Industry 4.0

### Walter Weigel

Vice President, Huawei European Research Institute, Belgium



Wednesday, 20 June, 9:00-10:30, Room Linhart hall

Vertical industries and applications have been among the key use cases fostering 5G research in the past years, driving the definition of new generation wireless technologies. Autonomous driving, digital factories, remote surgery, just to mention a few well known cases, posed hard challenges to cellular communication systems, as they require ultra-low latency and ultra-high reliability connectivity, potentially for massive number of devices and sensors. Solutions to such challenges are now coming to maturity and being standardized for the early drop of 5G end to end systems, which will enable a plethora of new services and business. Within this framework, this presentation will give some insights in these scenarios comprising real 5G tests and the design of the radio interface.

*Dr. Walter Weigel graduated from the Technical University in Munich, Germany, with the Master Degree in electrical engineering in 1984 and with the Ph. D. degree in 1990. From 1984 to 1991 he was assistant professor at the Institute of Data Processing at the Technical University in Munich. Dr. Weigel is since 1st April 2015 CSO and VP of the European Research Institute of Huawei, based in Leuven, Belgium and Munich, Germany. He was from September 2006 to July 2011 the Director General of the European Telecommunication Standards Institute ETSI. Between February 1991 and February 2015 he held several positions within Siemens AG, including VP of External Cooperations and Head of Standardization in Corporate Technology, VP of the Research & Concepts-department of the Mobile Networks business unit as well as Head of the business segment Video Processing for the semiconductor business unit (today Infineon). He is a lecturer at the Technische Universitaet Muenchen, member of the Innovationsdialog of the German Government and of the Aalborg University Industry Advisory Council, member of the Senate of Acatech (German academy of technical sciences) and of the Board of 5GAA, former member of the IEEE Board of Governors as well as of the Key Enabling Technologies working group of DG Grow.*



## Rising Power of the Network User

### Biswanath Mukherjee

*Distinguished Professor of Computer Science, University of California, Davis, USA*



Wednesday, 20 June, 9:00-10:30, Room Linhart hall

The network user, armed with increasingly-capable smart devices, is becoming more powerful. The user is demanding that newer IT infrastructures, e.g., Beyond 5G – consisting of the communication networks, (edge and cloud) data centers, distributed network functions, etc. – become more agile, and the services they facilitate become more application-centric, leading to exceptional user experience. For the network user, it is no longer satisfactory for the infrastructure operators to claim that their newer resources can support many orders of magnitude higher bandwidth and much lower latency by focusing on only the lower layers of the protocol stack (Layers 1-3). Noting that different applications have different tolerances to available bandwidth, latency, etc., novel methods are required to develop real-time application-centric user-experience analytics for future IT infrastructures. Given the huge data volumes involved, appropriate AI and machine-learning methods need to be applied.

*Biswanath Mukherjee received the BTech (Hons) degree from Indian Institute of Technology, Kharagpur (1980) and PhD from University of Washington, Seattle (1987). He was General Co-Chair of IEEE/OSA Optical Fiber Communications (OFC) Conference 2011, TPC Co-Chair of OFC'2009, and TPC Chair of IEEE INFOCOM'96. He is Editor of Springer's Optical Networks Book Series. He has served on 8 journal editorial boards, most notably IEEE/ACM Transactions on Networking and IEEE Network. He has supervised 72 PhDs and currently mentors 12 advisees, mainly PhD students. He is winner of the 2004 Distinguished Graduate Mentoring Award, the 2009 College of Engineering Outstanding Senior Faculty Award, and the 2016 UC Davis International Community Building Award at UC Davis. He is co-winner of 11 Best Paper Awards, mostly from IEEE conferences. He is author of the textbook Optical WDM Networks (Springer, January 2006). He is Founder and President of Ennetix, Inc. He is winner of the IEEE COMSOC's inaugural Outstanding Technical Achievement Award "for pioneering work on shaping the optical networking area". He is an IEEE Fellow.*



# TECHNICAL, SPECIAL AND POSTER SESSIONS





# Tuesday, June 19

Tuesday, June 19 2018, 09:00 – 11:00

## Linhart hall

Chairs:

**Mojca Volk**

*University of Ljubljana*

**Mihael Mohorčič**

*Jožef Stefan Institute*

## OPENING AND WELCOME ADDRESSES

**Mojca Volk,**

*Assistant Professor and Strategic Partnerships Manager,  
University of Ljubljana, Slovenia*

**Mihael Mohorčič**

*Associate Professor and Scientific Councillor, Jožef  
Stefan Institute, Slovenia*

**Boris Koprivnikar**

*Deputy Prime Minister and Minister of Public  
Administration of the Republic of Slovenia*

**Pearse O'Donohue**

*Director for the Future Networks, DG CONNECT, EC &  
Conference General Co-Chair*

**Bojan Križ**

*Director General of the Information Society Directorate  
at the Ministry of Public Administration of the Republic  
of Slovenia*

## KEYNOTES

**Business model-driven 5G deployment**

**Michele Zarri**

*Technical Director, GSM Association, United Kingdom*

**THz communications – an option for wireless  
networks beyond 5G?**

**Thomas Kürner**

*University Professor, Institut für Nachrichtentechnik,  
Germany*

## EXHIBITION OPENING AND COFFEE BREAK & PITCH CORNER

11:00 – 11:30, Foyer 1

Ljubljana, Slovenia

Tuesday, June 19 2018, 11:30 – 13:00

## PHY1: NEW CODING AND MODULATION SCHEMES

### E1 hall

Chair:

**Tomaž Javornik**

*Jožef Stefan Institute, Slovenia*

- Turbo-FSK, a Physical Layer for LPWA:  
Synchronization and Channel Estimation  
*François Dehmas, Valerian Mannoni, Vincent Berg*
- A Polar Code Hybrid Rate Matching Scheme  
*Fengjun Xi, Chanxuan Ye, Robert L. Olesen*
- Achievable Rates for HDF WPNC Strategy with  
Hierarchical Bit-Wise Network Coding Maps for  
Higher-Order Constellations in H-MAC Channel  
with Relative Fading  
*Jan Sykora, Petr Hron*
- Quantifying the Gain of Multi-Connectivity in  
Wireless LAN  
*Nick Schwarzenberg, Albrecht Wolf, Norman Franchi,  
Gerhard Fettweis*
- A Distribution-Free Analysis of Outage Probability  
over Block Fading Channels  
*Jinho Choi*

## NET1: Network slicing

### E2 hall

Chair:

**Jordi Perez-Romero**

*Universitat Politècnica de Catalunya, Spain*

- 5GTANGO: A Beyond-MANO Service Platform  
*Carlos Parada, Jose Bonnet, Eleni Fotopoulou,  
Anastasios Zafeiropoulos, Evgenia Kapassa, Marios  
Touloupou, Dimosthenis Kyriazis, Ricard Vilalta, Raul  
Muñoz, Ramon Casellas, Ricardo Martinez, George K  
Xilouris*
- The Creation Phase in Network Slicing: From a  
Service Order to an Operative Network Slice  
*Jose Ordonez-Lucena, Oscar Adamuz-Hinojosa,  
Pablo Ameigeiras, Pablo Muñoz, Juan J. Ramos-  
Muñoz, Jesus Folgueira Chavarria, Diego Lopez*
- On the Automation of RAN Slicing Provisioning  
and Cell Planning in NG-RAN  
*Ramon Ferrús, Oriol Sallent, Jordi Pérez-Romero,  
Ramon Agustí*

- Profit-Aware Resource Allocation for 5G Sliced Networks  
*Sunday Oladejo, Olabisi Emmanuel Falowo*
- 5GaaS with SDN-based UPF for Mobile Backhaul Network Slicing  
*Jose Costa-Requena*

## RAS1: Radio resource management and cell planning

### E3 hall

Chair:

**Hugo M. Tullberg**

*Ericsson Research, Sweden*

- A Game-Theoretic Approach for NOMA-ALOHA  
*Jinho Choi*
- Performance of Neighboring Indoor 5G Micro Operators with Dynamic TDD  
*Kimmo Hiltunen, Marja Matinmikko-Blue*
- Breaking the Access Technologies Silos by Enhancing MAC and RRM in 5G+ Networks  
*Valerio Frascolla, Bismark Okyere, Andreas Georgakopoulos, Evangelos Kosmatos, Aspa Skalidi, Panagiotis Demestichas, Benoit Miscopein, Antonio De Domenico, Rida El Chall, Jérémy Estavoyer, Seiamak Vahid, Marcin Filo, Klaus Moessner, Shahid Mumtaz, Jonathan Rodriguez, Kazi Mohammed Saidul Huq, Thanasis Oikonomou, Dimitrios Kritharidis, Panagiotis Panagiotopoulos, Panteleimon-Konstantinos Chartsias, Keith Briggs, Uwe Herzog*
- Traffic-aware Resource Allocation with Aggregation in Heterogeneous Networks with WLANs  
*Haeyoung Lee, Seiamak Vahid, Klaus Moessner*
- Concept Design of QoS Oriented MAC for 5G Spectrum Access Systems in 3.5 GHz  
*Ziad Youssef, Erfan Majeed, Markus Dominik Mueck, Ingolf Karls, Christian Drewes, Guido Bruck, Peter Jung*

## WOS1: Wireless and optical backhaul

### E4 hall

Chair:

**Boštjan Batagelj**

*University of Ljubljana, Slovenia*

- Software Defined Control of Tunable Optical Transceivers Using NETCONF and YANG  
*Sean Ahearne and Yuliya Verbishchuk, Fatima C Garcia-Gunning, Cormac J. Sreenan*
- Grade of Service in UDWDM-PON with Statistical Wavelength Subscribing  
*Josep Segarra, Vicent Sales and Josep Prat*

- Application of an Opto-Electronic Oscillator in 5G Mobile and Wireless Networks with a Low Frequency Drift, a High Side-Modes-Suppression Ratio and Without a Power Penalty Due to Chromatic Dispersion  
*Mehmet Alp Ilgaz, Bostjan Batagelj*
- Meshed Backhauling of Small Cells Using IEEE802.11ad at 60GHz  
*Peter J Legg and Ray McConnell*
- Architecture Options for Satellite Integration into 5G Networks  
*Boris Tiomela Jou, Oriol Vidal, Fabrice Arnal, Konstantinos Liolis, Mael Boutin, Joe Cahill, Pouria Sayyad Khodashenas, Jean-Michel Houssin, Hamzeh Khalili, Duy Kha Chau, Salva Diaz Sendra*

## SPS11: Unlocking the 5G potential for smart energy grids

### Štih hall

Chair:

**Massimo Bertoncini**

*Engineering Ingegneria Informatica, Italy*

- Invited Talk: How Smart Energy grids may gain benefits from 5G: SUCCESS, RESERVE and SOGNO projects  
*G. Lipari*
- Invited Talk: 5G for smart energy grids – a use case oriented overview  
*M. Bertoncini*
- 5G-Cognitive Drone System for Preventive Maintenance in Energy Infrastructures  
*N. Sanchez, J. M. Lalueza, A. Voulkidis, T. Zahariadis, D. Barthel, A. Frederic*
- Smart Energy as a Service Network Architecture  
*T. Zahariadis, S.Voliotis, H.C. Leligou, P. Trakadas, M. R. Spada, A. Gonos*
- NRG-5: Synergies to Improve the 5G Ecosystem  
*M. R. Spada, A. Corsi, G. Fiorentino, F. Rebecchi*

## SPS12: Wireless network research: think outside the box

### Linhart hall

Chairs:

**Carolina Fortuna**

*Jožef Stefan Institute, Slovenia*

- Flexible RAN beyond 5G  
*Huseyin Arslan, University of South Florida, USA*



- Radio Resource and Network Management for 5G New Radio and Beyond: Shifting the Focus  
*Oriol Sallent, Universitat Politècnica de Catalunya, Spain*
- The radio challenges for future terminals  
*Luis M. Correia, IST - University of Lisbon, Portugal*
- Horizon 2028: The Dawn of True Mobile Radio Networks?  
*Roberto Verdone, University of Bologna, Italy*
- Wireless 2035: New Technologies or New Architectures?  
*Renato Lo Cigno, University of Trento, Italy*
- Driving digital transformation through converged network architectures, AI and new business models  
*Dimitra Simeonidou, University of Bristol, United Kingdom*

## LUNCH

13:00 – 14:00 Foyer 1

Tuesday, June 19 2018, 14:00 – 14:30

## POSTER SESSION 1

### Foyer 2

Chair:

**Aleš Švigelj**

*Jožef Stefan Institute*

- Data Transformation Model for the Fault Management of Multi-tenant Networks  
*Sihem Cherrared, Sofiane Imadali, Eric Fabre, Gregor Goessler*
- Design of Water Level Measurement Wireless Node for Remote Areas  
*Minja Miladinović, Andrej Hrovat, Tomaž Javornik*
- Fade Duration Analysis of Ka- And Q-band Satellite Beacon Measurements in Ljubljana  
*Arsim Kelmendi, Andrej Vilhar*
- A Beneficial Use of Crossed-Slot in Dynamic Time-division Duplexing  
*Hyun Geon Kim, Ho-Shin Cho*
- Coded Caching for Optimal Content Delivery in 5G: The Case of Low Cache Sizes  
*Seyed Pooya Shariatpanahi, Babak Hossein Khalaj*
- Multi-RAT Experimentation Below 6 GHz  
*Nicola Michailow, Clemens Felber, Vincent Kotzsch*
- Optimal Optical Filter Design for Optical Wireless Communications  
*Kang-Il Ahn, Jae Kyun Kwon*

- Grant-Free Transmissions for Ultra-Reliable and Low Latency Uplink Communications  
*Bikramjit Singh, Olav Tirkkonen, Zexian Li, Mikko Uusitalo*
- WiFi-ZigBee Coordination Using Spectrum Sensing and Edge Computing  
*Nenad Milosevic, Valentina Nejtkovic, Zorica Nikolic, Milorad Tosic*
- Internet of Radio-Light - H2020 Project 1st Year Achievements  
*John Cosmas, Adam Kapovits*
- Practical Implementation of Cloud-RAN: FALCON's Approach  
*Valentin Rakovic, Daniel Denkovski, Liljana Gavrilovska*
- Real-Time Connectivity Capabilities of Cellular Network for Smart Grid Applications  
*Miha Smolnikar, Marko Mihelin, German Corrales Madueno*
- Pilot Contamination in Massive MIMO: Virtual Angular Information Aided Channel Estimation  
*Andrea P Guevara*
- A Comparison of Shaping Techniques for Wireless Backhaul Channel  
*Najeeb Ul Hassan, Wen Xu, Anastasios Kakkavas*
- Method to Design UF-OFDM Filter and Its Analysis  
*Hirofumi Tsuda, Ken Umeno*
- Architecture and Enablers of 5G V2X Network Slice for Reliable and Low-latency Communications  
*Apostolos Kousaridas, Panagiotis Spapis, Laurent Gallo and Bernadette Villeforceix, YunXi Li, Wanlu Sun, Massimo Condoluci, Liang Hu, Toktam Mahmoodi, Ricard Vilalta, Markus Dillinger*
- Distributed Ledger Technology-Based Ownership Management in Social IoT  
*Jernej Mihelj, Andrej Kos, Urban Sedlar*
- Wireless Information and Energy Transfer for Outdoor to Indoor Multicarrier SUDAS  
*Syed Adil Abbas Kazmi, Sinem Coleri Ergen*
- Enabling Advanced 5G Component Validations and Optimizations by Means of System Level Simulations Platform, Abstractions, Models, Results and Further Challenges  
*Andreas Georgakopoulos, Evangelos Kosmatos, Ioannis-Prodromos Belikaidis, Martin Kurras, Lars Thiele, Panagiotis Demestichas*

Tuesday, June 19 2018, 14:30 – 16:00

## PANEL 1

### Linhart hall

Chair:

#### Markus Dillinger

*Huawei Technologies Duesseldorf GmbH, Germany*

#### 5G for Verticals: Evolving Requirements, deployment challenges and business cases

*Markus Dillinger, Li Zexian, Mikael Fallgreen, Mikael Nilsson, Andreas Mueller, Bo Andersson*

## COFFEE BREAK & PITCH CORNER

16:00 – 16:30 Foyer 1

Tuesday, June 19 2018, 16:30 – 18:00

## PHY2: Advanced and massive MIMO systems

### E1 hall

Chair:

#### Venceslav Kafedziski

*SS. Cyril and Methodius University, Macedonia, the former Yugoslav Republic of*

- Energy-efficient Sources and Relay Precoding Design for Two-way Two-hop MIMO-AF Systems  
*Fengjun Xi, Chanxuan Ye and Robert L. Olesen*
- Energy-efficient Joint Source and Relay Precoding for Two-hop MIMO-AF Two-Relay Networks  
*Fabien Hélot, Rahim Tafazolli*
- Amplitude Quantization for Type-2 Codebook Based CSI Feedback in New Radio System  
*Honglei Miao, Markus Dominik Mueck, Michael Faerber*
- Space-Time Shift Keying and Constant-Envelope OFDM: A New Solution for Future Mm-wave MIMO Multicarrier Systems  
*Talha Faizur Rahman, Claudio Sacchi*
- Compressed Sensing Based Channel Estimation in FDD Multi-user Massive MIMO Using Angle Domain Sparsity and Transmit Antenna Correlation  
*Venceslav Kafedziski*

## NET2: Network function virtualization and orchestration

### E2 hall

Chair:

#### Raul Muñoz

*Centre Tecnològic de Telecomunicacions de Catalunya, Spain*

- Programmable and Flexible Management and Orchestration of Virtualized Network Functions  
*Hadi Razzaghi Kouchaksaraei, Sevil Dräxler, Manuel Peuster, Holger Karl*
- Pragmatic Approach of Determining Heavy-Hitter Traffic Thresholds  
*Sourav Maji, Xiaoyu Wang, Malathi Veeraraghavan, Jordi Ros-Giralt, Alan Commike*
- Policy Framework for the Next Generation Platform as a Service  
*Angelos Mimidis Kentis, Eder Ollora Zaballa, Jose Soler*
- Enabling Vertical Industries Adoption of 5G Technologies: a Cartography of Evolving Solutions  
*Anastasios Zafeiropoulos, Panagiotis Gouvas, Eleni Fotopoulou, George Tsiolis, Thanos Xirofotos, Jose Bonnet, Gino Carrozzo, Stamatia Rizou, Anastasius Gavras, Maria Barros Weiss, Xavier Costa-Perez, Athul Prasad, Marco Gramaglia, Anna Tzanakaki, Dimitra Simeonidou, John Cosmas, Mikael Fallgren, Raul Muñoz, Ricard Vilalta*
- BlueSPACE's SDN/NFV Architecture for 5G SDM/WDM-enabled Fronthaul with Edge Computing  
*Raul Muñoz, Giada Landi, Ricard Vilalta, Josep M. Fabrega, Marco Capitani, Laura Rogríquez, Ricardo Martinez, Ramon Casellas*

## RAS2: Radio access performance optimization

### E3 hall

Chair:

#### Ingrid Moerman

*Ghent University - IMEC, Belgium*

- Knapsack Optimisation Versus Cell Range Expansion for Mobility Load Balancing in Dense Small Cells  
*Karim M. Nasr, Klaus Moessner*
- Load Balancing and Control Using Particle Swarm Optimisation in 5G Heterogeneous Networks  
*Tareq M. Shami, David Grace and Alister G. Burr*

- Compute Resource Disaggregation: An Enabler for Efficient 5G RAN Softwarisation  
*Nikolaos Gkatzios, Markos Anastasopoulos, Anna Tzanakaki, Dimitra Simeonidou*
- Model Predictive Network Control and Throughput Sub-Optimality of MaxWeight  
*Richard Schoeffauer, Gerhard Wunder*

## WOS2: Latency and reliability in wireless networks

### E4 hall

Chair:

#### Lena Wosinska

*Royal Institute of Technology KTH, Sweden*

- MEC-assisted End-to-End Latency Evaluations for C-V2X Communications  
*Mustafa Emara, Miltiades C. Filippou, Dario Sabella*
- Asymmetric ACK/NACK Detection for Ultra-Reliable Low-Latency Communications  
*Hamidreza Shariatmadari, Ruifeng Duan, Sassan Raji, Riku Jäntti, Zexian Li, Mikko Uusitalo*
- Handling Delay in 5G Ethernet Mobile Fronthaul Networks  
*Steinar Bjornstad, David T Chen, Raimena Veisllari*
- Latency Aware NOMA Based Device-to-Device Communication  
*Bilge Kartal, Nuno K Pratas*
- Assessment of the Suitability of NB-IoT Technology for ORM in Smart Grids  
*Varun Nair, Remco Litjens, Haibin Zhang*

## SPS9: Critical communications and public safety – national and EU perspectives

### Štih hall

Chair:

#### Marie-Christine Bonnamour

*Public Safety Communications Europe, Belgium*

- Practitioner's view on 5G potential  
*Manfred Blaha*
- European perspective: Pre-Commercial Procurement for Pan-European Interoperable Broadband Public Safety Communication Network  
*Sanja Holen*
- Slovenian ecosystem for 5G vertical PPDR  
*Bojan Križ*

## SPS1: 5G-PPP Phase 3 introduction & ICT-19-2018 info-session

### Linhart hall

Chair:

#### David Kennedy

*Eurescom, Germany*

- Welcome & Introduction  
*Bernard Barani, Colin Wilcock*
- Projects presentations  
*5G EVE, Anastasius Gavras*  
*5G-VINNI, Pål Grønsund*  
*5GENESIS, Harilaos Koumaras*
- Q&A session
- Ambition of ICT 19  
*Pavlos Fournogerakis*
- Pre-structuring concept for ICT 19  
*Didier Bourse*

## Announcement of the 5G-PPP Brokerage service for ICT-19 2018

## WELCOME RECEPTION

18:00 – 20:00 Foyer 1



# Wednesday, June 20

Wednesday, June 20 2018, 09:00 – 10:30

## Linhart hall

Chair:

**Luis M. Correia**

IST – University of Lisbon, Portugal

## KEYNOTES

### 5G applied to vertical industry use cases – car, health, and industry 4.0

Walter Weigel, Vice President, Huawei European Research Institute, Belgium

### Rising power of the network user

Biswanath Mukherjee, Distinguished Professor of Computer Science, University of California, Davis, USA

## COFFEE BREAK & PITCH CORNER

10:30 – 11:00 Foyer 1

Wednesday, June 20 2018, 11:00 – 12:30

## PHY3: Millimeter-wave communications and antenna arrays

### E1 hall

Chair:

**Didier Bourse**

Nokia, France

- Total Array Gains of Polarized Millimeter-Wave Mobile Phone Antennas  
*Katsuyuki Haneda, Mikko Heino, Jan Järveläinen*
- Out-of-Band Interference in 5G mmW Multi-Antenna Transceivers: Co-existence Scenarios  
*Marko E Leinonen, Nuutti Tervo, Olli Kursu, Aarno Pärssinen*
- Effects of Unit Cell Enlargement and 1-Bit Quantization in 5G Linear Metasurface Antennas  
*Xavier Artiga*
- Approaching Two Dimensional Mazon Limit: A Novel Non-orthogonal Waveform with Inter-carrier Zero Correlation Window  
*Fan Yang*

- Transmission Hub and Terminals for Point to Multipoint W-band TWEETHER System  
*Claudio Paoloni, François Magne, Frederic Andre, Joel Willebois, Quang Trung Le, Xavier Begaud, Giacomo Ulisse, Viktor Krozer, Rosa Letizia, Marc Marilier, Antonio Ramirez, Ralph Zimmerman*

## NET3: Network slicing management

### E2 hall

Chair:

**Panagiotis Demestichas**

University of Piraeus, Greece

- 5G OS: Control and Orchestration of Services on Multi-Domain Heterogeneous 5G Infrastructures  
*Sevil Dräxler, Holger Karl, Hadi Razzaghi Kouchaksaraei, Azahar Machwe, Crispin Dent-Young, Kostas Katsalis, Konstantinos Samdanis*
- Emulation-based Smoke Testing of NFV Orchestrators in Large Multi-PoP Environments  
*Manuel Peuster, Michael Marchetti, Gerardo García de Blas, Holger Karl*
- The Vertical Slicer: Verticals' Entry Point to 5G Networks  
*Claudio E. Casetti, Carla Fabiana Chiasserini, Thomas Deiss, Jose Enrique González Blázquez, Giada Landi, Josep Mangles-Bafalluy, Jorge Martín-Pérez, Nuria Molner, Cao-Thanh Phan, Farouk Messaoudi, Nicolás Serrano, Charles Turyagyenda*
- Transactional Network Updates in SDN  
*Maja Curic, Zoran Despotovic, Artur Hecker, Georg Carle*
- Cross-domain Network Slicing for Industrial Applications  
*Vasileios Theodorou, Konstantinos V. Katsaros, Andreas Roos, Ermin Sakic, Vivek Kulkarni*

## SPS8: Spectrum issues, from cognitive radio to spectrum sharing

### E3 hall

Chair:

**Ingrid Moerman**

IMEC – Ghent Univ., Belgium

### Panelists:

- Regulatory issues related to spectrum sharing  
*Jorge Pereira*

- Project presentations  
Wi-5: a spectrum programming architecture for Wi-Fi networking  
*Faycal Bauhaus*  
WiSHFUL, an enabler towards an efficient and transparent spectrum sharing universal strategy  
*Spilios Giannoulis*  
Monitoring and Context Awareness for Coexistence in Shared Spectrum  
*Luiz DaSilva*  
Infrastructure and Spectrum Sharing for Massive MIMO: A Measurement-Based Study  
*Andrea Guevara*
- Panel discussion
- Closing panel

## SPS7: Satellite solutions for the 5G network of networks

### E4 hall

Chairs:

**Georgia Poziopoulou**

*Avanti Communications, UK*

**Adam Kapovits**

*Eurescom GmbH, Germany*

**Maria Guta**

*European Space Agency, France*

- ESA Satellite for 5G Initiative Technology Developments, Validation Trials and Pilots  
*Maria Guta*
- Scenarios for Integration of Satellite Components in a 5G System and Associated Standardization Impacts  
*Nicolas Chuberre, Jean-Michel Houssin, Fabrice Arnal, Cyril Michel, Mathias Van Den Bossche and Christophe Nussli*
- Demonstrating satellite integration in 5G networks – SaT5G's eMBB use cases  
*Yogarathnam Rahulan*
- SATis5 – a satellite-terrestrial testbed showcasing different use cases  
*Marius-Iulian Corici*
- Japanese plans for satellite-terrestrial integration testing activities  
*Naoto Kadowaki*
- The Connected Globe – Satellite's Role for the Future  
*Indran Sivarajah*
- Large scale experimental platforms and satellites  
*Anastasios Gavras*
- Closing thoughts by session chairs

## APP1: Key technologies for application areas

### Štih hall

Chair:

**Ralph Stuebner**

*COST Association, Belgium*

- Interoperability and Decentralization as Key Technologies for Future Smart Urban Environments  
*Marcin Plociennik, Mario Drobits, Ivana Podnar Zarko, Konstantinos V. Katsaros, Sergios Soursos, Ivan Gojmerac*
- Combining Measurements and Simulations for Evaluation of Tracking Algorithms  
*Klemenregar, Roman Novak, Mihael Mohorčič*
- Interference Coordination in Ultra-Reliable and Low Latency Communication Networks  
*Bikramjit Singh, Olav Tirkkonen, Zexian Li, Mikko Uusitalo*
- Smart Contracts for the Internet of Things: Opportunities and Challenges  
*Nikos Fotiou, George C. Polyzos*
- Factors Influencing Market Adoption and Evolution of NFV/SDN Cybersecurity Solutions. Evidence from SHIELD Project  
*Dimitrios Katsianis, Ioannis Neokosmidis, Antonio Pastor, Ludovic Jacquin, Georgios Gardikis*

## OPE1: Testbeds, pilots and DevOps

### Linhart hall

Chair:

**Ivan Seskar**

*WINLAB, Rutgers University, USA*

- 5GTANGO: An Approach for Testing NFV Deployments  
*Peter Twamley, Marcel Müller, Patrick-Benjamin Bök, George K Xilouris, Christos Sakkas, Manuel Peuster, Stefan Schneider, Michail Alexandros Kourtis, Dimosthenis Kyriazis, Panagiotis Stavrianos*
- A Real World Information-Centric Connected Vehicle Testbed Supporting ETSI ITS-G5  
*Dennis Grewe, Andong Tan, Marco Wagner, Sebastian Schildt, Hannes Frey*
- MONICA in Hamburg: Towards Large-Scale IoT Deployments in a Smart City  
*Sebastian Meiling, Dorothea Purnomo, Julie-Ann Shiraishi, Michael Fischer, Thomas C. Schmidt*

- Integrating Research Testbeds into Social Coding Platforms  
*Matevž Vučnik, Carolina Fortuna, Tomaž Šolc, Mihael Mohorčič*
- Dev-for-Operations and Multi-sided Platform for Next Generation Platform as a Service  
*Bela Berde, Steven Van Rossem, Aurora Ramos, Matteo Orru, Anas Shatnawi*

## LUNCH

12:30 – 13:30 Foyer 1

Wednesday, June 20 2018, 13:30 – 14:00

## POSTER SESSION 2

### Foyer 2

Chair:

#### Urban Sedlar

University of Ljubljana

- How 5G Will Impact on Vertical Industries 5G Network Slicing Enabling Smart Energy-as-a-Service  
*Giampaolo Fiorentino, Antonello Corsi*
- Towards 5G as a Service for over the Top Players  
*Sofiane Imadali, Ayoub Bousselmi, Xavier Campderros, Juan Gascon, Gregory Akpoli-Johnson, Marion Duprez*
- From Community Networks to Community Data: The AppLea Farming Mobile App  
*Aristeidis Pilichos, Merkourios Karaliopoulos, Iordanis Koutsopoulos*
- The 5GinFIRE Platform – A Testbed for End-To-End 5G Experimentation  
*Anastasius Gavras, Halid Hrasnica, Spyros Denazis, Christos Tranoris*
- SliceNet: E2E Cognitive Network Slicing and Slice Management in 5G Networks  
*Anastasius Gavras, Maria Barros Weiss, Qi Wang, Jose Maria Alcaraz Calero*
- Enabling Experimental Research Through Converged Orchestration of Optical Wireless and Cloud Domains  
*Cristina Dominicini, Magnos Martinello, Cristiano Bonato Both, Juliano Araujo Wickboldt, Reza Nejabati, Daniel Fernandes Macedo, Johann M. Marquez-Barja, Luiz DaSilva*
- SAAM: Supporting Active Ageing – Use Cases and User-Side Architecture  
*Andrej Hrovat, Martin Žnidaršič, Bernard Zenko, Matevž Vučnik, Mihael Mohorčič*
- CityLab: A Flexible Large-scale Multi-technology Wireless Smartcity Testbed  
*Jakob Struye, Bart Braem, Steven Latré, Johann M. Marquez-Barja*
- Enabling Smart Retail Through 5G Services and Technologies  
*Nikos Stasinopoulos, Claudio Meani, Pietro Paglierani, Panagiotis Demestichas, Kostas Tsagkaris, Athina Ropodi*
- A 5G NFV Test Bed for the Evaluation of AI Based Network Management and Security (Concepts)  
*Mathias Strufe, Wei Jiang, Hans Schotten*
- Last Level Cache Partitioning to Protect Multi-Tenant VNFs from Noisy Neighbors  
*Paul Veitch, Tomasz Kantecki*
- Metro-Haul: Supporting Autonomic NFV Services over Disaggregated Optical Networks  
*Ramon Casellas, Sergio Llana, Lluís Gifre Renom, Ricard Vilalta, José Luis Izquierdo Zaragoza, Raul Muñoz, Marc Ruiz, Ricardo Martinez, Luis Velasco*
- On the Design of 5G End-to-End Facility for Performance Evaluation and Use Case Trialling  
*Kashif Mahmood, Pål R. Grønsund, Anastasius Gavras, David Kennedy, Dan Warren, Christos Tranoris, Andrea F. Cattoni, Eleonora Cau, Paul Muschamp*
- A 5G Framework for the Next Generation In-Flight Entertainment and Communications (NG-IFEC)  
*Elisa Jimeno, Javier Fernandez Hidalgo, Miguel Catalan-Cid, Pouria Sayyad Khodashenas, Jose Escobar Soriano, August Betzler, Elisenda Temprado Garriga, Leonardo Goratti*
- SliceNet: Enabling 5G Use Cases for Vertical Businesses  
*Ana Aleixo, Jose Maria Alcaraz Calero, Maria Barros Weiss, Giacomo Bernini, Giuseppe Celozzi, Rogério Paulo, Anastasius Gavras, Marius Iordache, Elena Oproiu, Mark Roddy, Alberto Rodrigues, Eduardo Rodrigues, Salvatore Spadaro, Paul Walsh, Qi Wang*
- Plug'in: A 5G Experimentation Platform for Collaborative and Reproducible Research  
*Ayoub Bousselmi, Sofiane Imadali, Marion Duprez*
- EuWireless: Design of a pan-European Mobile Network Operator for Research  
*Pedro Merino, Laura Panizo, Almudena Diaz Zayas, Janie Baños, Oscar Castañeda, Atso Hekkala, Kyosti Rautiola, Jarno E. Pinola, Adam Flizikowski, Slawomir Pietrzyk, Jos Dumortier, Lars Fischer, Jerry Sobieski*
- The isITethical? ExchangeSupporting Responsible Research and Innovation (RRI) in 5G and Beyond  
*Monika Büscher*



Wednesday, June 20 2018, 14:00 – 15:30

## PANEL 2

### Linhart hall

Chair:

#### Kostas Pentikousis

Traveling GmbH, Germany

#### Network Slicing: Real-world Opportunities with Open Standards and Open Source

Kostas Pentikousis, Antje Williams, Dirk Trossen, Navid Nikaein, Rebecca Steinert

## COFFEE BREAK & PITCH CORNER

15:30 – 16:00 Foyer 1

Wednesday, June 20 2018, 16:00 – 17:30

## SPS3: Terabit wireless transport for networks beyond 5G

### E1 hall

Chair:

#### Claudio Paoloni

Lancaster University, United Kingdom

- Next-Generation Channel Coding Towards Terabit/s Wireless Communications  
*Norbert When, Onur Sahin*
- TERAPOD: Building an End User Focused THz Based Ultra High Bandwidth Wireless Access Network  
*Alan Davy, Luis Pessoa, Cyril Renaud, Edward Wasige, Mira Naftaly, Thomas Kürner, Glenn George, Oleg Cojocari, Niamh O' Mahony, Marco A. Porcel*
- TERRANOVA System Architecture Reliable and Scalable Tbit/s Connectivity to Extend the Fibre Optic Systems QoE into the Wireless Domain  
*Angeliki Alexiou*
- Ultra Capacity Wireless Layer Beyond 100 GHz Based on Millimeter Wave Traveling Wave Tubes  
*Claudio Paoloni*

## NET4: Fog, edge and cloud computing

### E2 hall

Chair:

#### Leonardo Goratti

Zodiac Aerospace, Germany

- Modelling of Computational Resources for 5G RAN  
*Sina Khatibi, Kunjan Shah, Mustafa Roshdi*
- Analyzing the Deployment Challenges of Beacon Stuffing as a Discovery Enabler in Fog-to-Cloud Systems  
*Zeineb Rejiba, Xavier Masip-Bruin, Eva Marín-Tordera*
- Multi-access Edge Computing: A 5G Technology  
*Carlos Parada, Francisco Fontes, Carlos Marques, Cristina Leitão, Vitor A Cunha*
- V-PMP: a VLIW Packet Manipulator Processor  
*Marco Spaziani Brunella, Salvatore Pontarelli, Marco Bonola and Giuseppe Bianchi*
- A Performance Benchmarking Analysis of Hypervisors Containers and Unikernels on ARMv8 and X86 CPUs  
*Ashijeet Acharya, Jérémy Fanguède, Michele Paolino, Daniel Raho*

## SPS4a: Resource elasticity for 5G network architecture

### E3 hall

Chair:

#### David Gutierrez Estevez

Samsung Electronics R&D Institute UK, UK

- Overall 5G-MoNArch Architecture and Implications for Resource Elasticity  
*David Gutierrez, Mehrdad Shariat*
- On the Benefits of Bringing Cloud-Awareness to Network Virtual Functions  
*Pablo Serrano*
- Dynamic Deployment of Virtual Network Functions in Heterogeneous Telco Clouds  
*Emilio Calvanese*
- Slice-Aware Elastic Resource Management  
*Sina Khatibi*
- The Economics of Network Elasticity  
*Julie Bradford*

## WOS3: Overlay and IoT networks

### E4 hall

Chair:

#### Gordana Gardašević

University of Banja Luka & Faculty of Electrical Engineering, Bosnia and Herzegovina

- Experimental Characterization of Joint Scheduling and Routing Algorithm over 6TiSCH  
*Gordana Gardasevic, Dragan Vasiljević, Chiara Buratti and Roberto Verdone*
- Overlay Inband D2D-e Network Using Fuzzy C-Means Clustering for Disaster Situations  
*Romain Chevillon, Guillaume Andrieux, Jean Francois Diouris*
- 5G and the Internet of EveryOne: Motivation, Enablers, and Research Agenda  
*Leonardo Maccari, Merkourios Karaliopoulos, Iordanis Koutsopoulos, Leandro Navarro, Felix Freitag, Renato Lo Cigno*
- Machine Learning for Terahertz Communication with Human-Implantable Devices  
*Kieran Sullivan, Martin Tolan*
- Enhance Information Derivation by In-Network Semantic Mashup for IoT Applications  
*Lijun Dong, Richard Li*

## APP2: 5G vertical application areas

### Štih hall

Chair:

#### Diego Lopez

Telefonica I+D, Spain

- Vertical Use Cases in the Finnish 5G Test Network  
*Teemu Kanstren, Jukka Mäkelä, Mikko Uitto, Olli Apilo, Ari T. Pouttu, Olli Liinamaa, Giuseppe Destino, Petri Kivinen, Arto Matilainen*
- Use Cases and Communications Architecture for 5G-enabled Road Safety Services  
*Tiia Ojanperä, Jukka Mäkelä, Olli Mämmelä, Mikko Majanen and Ossi Martikainen*
- Connected Vehicles Coordination: A Coalitional Game-Theory Approach  
*Jose Angel Leon Calvo, Rudolf Mathar*
- Secure Blockchain-Based Communication Scheme for Connected Vehicles  
*Jose Angel Leon Calvo, Rudolf Mathar*
- 5G Based Collision Avoidance - Benefit from Unobtrusive Activities  
*Andreas Jahn, Michel Morold, Klaus David*

## OPE2: Trials and experimentation

### Linhart hall

Chair:

#### Carolina Fortuna

Jožef Stefan Institute, Slovenia

- TVWS Field Trials with BF-OFDM  
*Jean-Baptiste Doré, Dimitri Kténas, Xavier Popon, David Dassonville, Patrick Rosson*
- Proof-of-Concept of Capacity Expansion Through Extended Dynamic Spectrum Access for 5G  
*Uwe Herzog, Keith Briggs, Thanasis Oikonomou, Dimitrios Kritharidis, Panagiotis Panagiotopoulos, Panteleimon-Konstantinos Chartsias, Aspa Skalidi, Christos Ntogkas, Andreas Georgakopoulos, Evangelos Kosmatos, Panagiotis Demestichas, Benoit Miscopein, Valerio Frascolla*
- An Adaptive Channel Quality Metric for Ultranarrowband Systems  
*Tomaž Šolc, Carolina Fortuna*
- IP over ICN Goes Live  
*George Xylomenos, Yannis Thomas, Xenofon Vasilakos, Michael Georgiades, Alexander Phinikarides, Ioannis Doumanis, Stuart Porter, Dirk Trossen, Sebastian Robitzsch, Martin J Reed, Mays F AL-Naday, George Petropoulos, Konstantinos V. Katsaros, Maria-Evgenia Xezonaki, Janne Riihijärvi*
- Feasibility of Gateway-less IoT E-health Applications  
*Carlos Pereira, Diana Guimarães, João Mesquita, Frederico Santos, Luis Almeida, Ana C Aguiar*

## GALA DINNER

19:00 – 23:00 Grand Union Hall



# Thursday, June 21

Thursday, June 21 2018, 09:00 – 10:30

## PHY4: Reconfigurable radios and hardware/software implementation

### E1 hall

Chair:

#### Dongwoo Kim

Hanyang University, Korea

- Universal Waveforms Processor  
*Martin Danneberg, Ahmad Nimr, Nicola Michailow, Shahab Ehsanfar, Maximilian Matthé, Ana Belen Martinez, Dan Zhang, Gerhard Fettweis*
- Performance Analysis of a 5G Transceiver Implementation for Remote Areas Scenarios  
*Wheberth Damascena Dias, Danilo Gaspar, Luciano Leonel Mendes, Marwa Chafii, Maximilian Matthé, Peter Neuhaus, Gerhard Fettweis*
- A Robust Decoding Method for OFDM Systems Under Multiple Co-channel Narrowband Interferers  
*Sumit Kumar, Florian Kaltenberger, Bernhard Kloiber, Alejandro Ramirez*
- Implementing 5G NR Features in FPGA  
*James Bishop, Jean Marc Chareau, Fausto Bonavitacola*
- Are the Data Rates Predicted by the Analytic Analysis of Receivers with Low Resolution ADCs Achievable  
*Kilian Roth, Hessam Pirzadeh, Lee Swindlehurst, Josef A. Nossek*

## SPS5: 5G Architecture towards verticals

### E2 hall

Chairs:

#### Simone Redana

Nokia Bell Labs, Germany

#### Ömer Bulakci

Huawei, Germany

- Operator pitches  
*Diego López, Telefonica Spain*  
*Paul Veitch, British Telecom*  
*Maria Rita Spada, WindTre*  
*Alexandros Kostopoulos, OTE*

- Vertical Industries view pitches  
*José Enrique Gonzalez, ATOS*  
*Luca Vignaroli, RAI*  
*Janez Sterle, INTERNET INSTITUTE*  
*Julie Bradford, Real Wireless*  
*Arturo Azcorra, Carlos J. Bernardos, Antonio de la Oliva, IMDEA*
- Vendors view pitches  
*Thomas Deiss, Christoph Schmelz, Nokia*  
*David Gutierrez/Mehrdad Shariat, Samsung*  
*Panagiotis Gouvas, Anastasios Zafeiropoulos, UBITECH*
- Closing panel discussion

## SPS4b: 5G mobile network architecture and new radio advances

### E3 hall

Chairs:

#### Frank Schaich

Nokia Bell Labs

#### Lars Christoph Schmelz

Nokia Bell Labs

#### Marie-Helene Hammon

Orange

#### Albert Banchs

University Carlos III Madrid, Spain

#### Gerhard Wunder

FU Berlin, Germany

#### Mauro Boldi

Telecom Italia, Italy

- Cognitive Network Fault Management Approach for Improving Resilience in 5G Networks  
*Borislava Gajic, Christian Mannweiler, Diomidis S. Michalopoulos*
- 5G Island for Network Resilience and Autonomous Failsafe Operations  
*Bin Han, Marcos Rates Crippa, Hans D. Schotten*
- Low-Overhead Massive MIMO Channel Estimation  
*Stelios Stefanatos, Gerhard Wunder, Samer Bazzi, Luc Le Magoarou, Stéphane Paquelet*
- On How to Harvest Multi-Channel Access Benefits in 5G New Radio  
*Daniela Laselva, Nurul H. Mahmood, Dong Min Kim, David Palacios, Isabel de la Bandera-Cascales, Mustafa Emara, Miltiades C. Filippou*



## SPS2: COST spotlight – COST actions on networks and communication

### E4 hall

Chair:

#### Ralph Stübner

COST Office, Belgium

- Welcome to COST  
*Ralph Stübner*
- IRACON: Inclusive Radio Communication Networks for 5G and Beyond  
*Gordana Gardašević, Claude Oestges*
- How Can Integrated Micro-Wave Photonics Help to Achieve the Demands of 5th-Generation Mobile and Wireless Communication Networks?  
*Bostjan Batagelj, José Capmany*
- On the Disaster Resiliency Within the Context of 5G Networks: The RECODIS Experience  
*Christian Esposito, Antonios Gouglidis, David Hutchison, Andrei Gurto, Bjarne E. Helvik, Poul E. Heegaard, Gianluca Rizzo, Jacek Rak*
- Always Connected Enhanced Living Environments  
*Nuno Garcia, Rossitza Goleva*
- Indoor Living Space Improvement: Smart Habitat for the Elderly  
*Michael Burnard, Francisco Metero*

## SPS6: Reality check for connected autonomous driving

### Štíh hall

Chairs:

#### Toktam Mahmoodi

King's College London, UK

#### Mikael Fallgren

Ericsson, Sweden

#### Tommy Svensson

Chalmers University of Technology, Sweden

#### Erik Ström

Chalmers University of Technology, Sweden

#### Jesus Alonso-Zarate

CTTC, Spain

#### Taimoor Abbas

Volvo Car Corporation, Sweden

#### Mate Boban

Huawei European Research Center, Germany

- Vision of Connected Autonomous Driving Telecom perspective  
*Maciej Muehleisen*
- Vision of Connected Autonomous Driving Automotive perspective  
*Mikael Nilsson*
- Vision of Connected Autonomous Driving Academia perspective, TBC  
*Tommy Svensson*
- Panel Discussion  
Moderator: Toktam Mahmoodi  
Panellist: Maciej Muehleisen, Mikael Nilsson, Markus Dillinger, Tommy Svensson

## SPS10: Small cells deployment, network functions virtualisation and cloud computing as “Enablers” of innovative 5G services

### Linhart hall

Chairs:

#### Ioannis Chochliouros

OTE, Greece

#### Ioannis Giannoulakis

NCSR, Greece

#### Maria-Rita Spada

WI3, Italy

#### Oriol Sallent

UPC, Spain

#### Jordi Perez-Romero

UPC, Spain

- Small Cells, NFV and Cloud Computing as Enablers for offering Innovative 5G Services: From the SESAME to the 5G ESSENCE Architectural Framework  
*Ioannis P. Chochliouros, Alexandros Kostopoulos, Anastasia S. Spiliopoulou, Anastasios Kourtis, Ioannis Giannoulakis, Michail-Alexandros Kourtis, Evangelos Sfakianakis, Maria Belesioti, Emmanouil Kafetzakis and Mike Iosifidis*
- 5G Edge Network Acceleration for a Stadium enabling Local Video Production and Distribution  
*Alexandros Kostopoulos, Ioannis P. Chochliouros, Daniele Munaretto and Claus Keuker*
- On the Support of NG-RAN Functional Splits in the 5G ESSENCE Architecture  
*Oriol Sallent, Jordi Pérez-Romero and Ramon Ferrús*
- 5G ESSENCE and 5G Italian MISE Trial: Synergies among the Use Cases  
*Maria-Rita Spada, Ioannis P. Chochliouros, Ioannis Giannoulakis and Anastasios Kourtis*

- The Impact of 3D Beamforming MIMO on 5G Mobile Networks  
*Konstantinos Filis, Elina Theodoropoulou, Ioanna Mesogiti and George Lyberopoulos*
- Crowdsourcing Mechanisms in the Privacy Flag Framework  
*Ioannis P. Chochliouros, Alexandros Kostopoulos, Anastasia S. Spiliopoulou, Sebastien Ziegler, Latif Ladid, Nancy Alonistioti, Maria Belesioti, Sotiris Nikoletseas, Vasileios Vlachos, Nenad Gligoric, Anna Stahlbrost, Luca Bolognini, Eirini Vasilaki, Dimitrios Arvanitosis and Evangelos Sfakianakis*
- Enhancing Critical Infrastructure Protection: The RESISTO Concept  
*Maria Belesioti, Ioannis P. Chochliouros, Leonardo Frosali and Rodoula Makri*
- Advancements in Cloud Computing to be Considered in 5G Network Deployments  
*George Lyberopoulos, Elina Theodoropoulou, Konstantinos Filis, Ioanna Mesogiti, Evangelos Sfakianakis, Daniel Baur, Lutz Schubert, John Violos, Fotis Aisopos, Alexandros Psychas and Gabriele Giammatteo*
- YAKSHA: Realising the Honeypot as a Service Concept  
*Alexandros Kostopoulos, Ioannis P. Chochliouros, Constantinos Patsakis and Nishant Shandilya*
- IoT in the Health Sector: Opportunities and Challenges coming from the VICINITY Context  
*Maria Belesioti, Ioannis P. Chochliouros, Viktor Oravec and Athanasios Tryferidis*

## COFFEE BREAK

10:30 – 11:00 Foyer 1

Thursday, June 21 2018, 11:00 – 12:30

## PANEL 3

### Linhart hall

Chair:

#### Arturo Azcorra

5TONIC Laboratory, Spain

#### Smart connectivity in the context of Next Generation Internet

Arturo Azcorra, Serge Fdida, Diego Lopez, Stefan Parkvall, Dimitra Simeonidou

Thursday, June 21 2018, 12:30 – 13:30

## CLOSING SESSION

### Linhart hall

Chairs:

#### Mojca Volk

University of Ljubljana

#### Mihael Mohorčič

Jožef Stefan Institute

#### EuCNC 2019

Narcis Cardona, EuCNC 2019 Host and TPC Chair

#### Status update on the 5GPPP Collaboration and moving ahead

Jean-Pierre Bienaimé, Secretary General, 5G Infrastructure Association (5G-IA)

#### Key event takeaways and next steps of the connectivity research and policy roadmap

Peter Stuckmann, Head of Unit – Future Connectivity Systems DG CONNECT, EC

## LUNCH

13:30 – 14:30 Foyer 1





PANELS



Logar Valley, photo Slovenia.info, Michael Matti



## 5G for Verticals: Evolving Requirements, deployment challenges and Business Cases

Organizer:

**Markus Dillinger**

*Huawei Technologies Duesseldorf  
GmbH, Germany*

Tuesday, 19 June, 14:30-16:00, Room Linhart hall

### Motivation and Background

Vertical industries like Automation Industry and Car Industry are expected to be the major topics in coming years for 5G networks. However, requirements are still evolving and sustainable business models and cases are still to be developed. An important ingredient are spectrum requirements for verticals in terms of licensed or unlicensed spectrum and the targeted amount of bandwidth. Cooperation models and business cases between involved stakeholders need to be created and monetized.

Moreover, to jointly identify standardization requirements roadmaps for 3GPP, ETSI, SAE, etc. and certification challenges is key in coming years. The panelist from verticals (e.g. car industry), telecom industry and academia will elaborate on business, technical and regulatory challenges to help identify the barriers for a potential market introduction.

### Questions

- What are the potential business cases and roles for 5G vertical stakeholders ?
- What is the role between public and private 5G networks ?
- What is the business model for service providers (e.g. drones, connected and autonomous driving, etc.) ?
- What are the spectrum licensing options and spectrum usage models for verticals ?
- What role and timeframe do you see for communication technologies and 5G to impact vertical business ?

### Participants

The panel is composed of:

**Chair: Markus Dillinger**

*Panel chair, Head for 5G verticals R&D, Munich, Germany*

**Li Zexian**

*Senior 5G researcher, Nokia Finland*

**Mikael Fallgreen**

*PM of 5GCar project Ericsson Research, Sweden*

**Mikael Nilsson**

*Volvo Cars, Sweden*

**Andreas Mueller**

*5G-ACIA board chair, Bosch, Germany*

**Bo Andersson**

*rapporteur for RSPG's working group on 5G*

## Panel 2

### Network Slicing: Real-world Opportunities with Open Standards and Open Source

Organizer:

**Kostas Pentikousis**

Traveling GmbH, Germany

Wednesday, 20 June, 14:00-15:30, Room Linhart hall

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#### Motivation and Background

Network slicing has captured the imagination of 5G business developers and fuelled the definition of a range of use cases during the last years. Researchers and industry alike have been looking into the system design and implementation aspects. As standards organizations picked up the pace in defining what network slicing means from an interoperability perspective, several aspects emerged ranging from trusted end-to-end isolation and resource efficiency to automation and full network slice lifecycle management to multi-domain support. In practice, network slicing is bound to be coupled with network function softwarization and service chaining in order to serve the diverse use cases stemming from the 5G scenarios (eMBB, mMTC, URLLC). This panel will present the mid-term real-world opportunities for operators bringing network slicing offerings to the market as well as the feedback from the end customers. The panel will discuss items that are key for the next phases of standardization as well as the road blocks that are still in place. Last but not least, based on the experience, current momentum, and established best practices in other domains, softwarization goes hand in hand with open source used originally for simple proofs of concept and increasingly entering the carrier-grade telco-clouds. Open source relates well with open standards and when combined can significantly lower the total cost of ownership (TCO) and speed up market velocity. The panel will review the use of open source in network slicing and debate which cases fit best a wider adoption of open source solutions.

#### Questions

- What is network slicing and how scattered is it at the moment?
- Technical/Research-related
  - From static resource isolation to dynamic resource control: are we there yet?
  - What are the challenges of network management and orchestration in multi-tenant scenarios?
  - What do the first results from trials with network slicing based on open source tell us?
  - OTT and network slicing: friends or foes?
- Deployment-related
  - How does the industry move towards network slicing reality?
  - Network slicing in practice: how many slices are realistic?
  - Open standards for network slicing: what is the current state and pain points?
  - What are the real-world opportunities for customer-driven end-to-end network slicing?
  - What is the role of network slicing in the carrier network 5 years from now?

## Participants

The panel is composed of :

### Chair: **Kostas Pentikousis**

*Business Development Manager, Traveling, Germany*

### **Antje Williams**

*Executive Program Manager, DTAG, Germany*

### **Dirk Trossen**

*Senior Principal Engineer, InterDigital Europe Ltd, United Kingdom*

### **Navid Nikaein**

*Professor, EURECOM, France*

### **Rebecca Steinert**

*Research Leader, RISE SICS, Sweden*





## Panel 3

### Smart connectivity in the context of Next Generation Internet

Organizer:

**Arturo Azcorra**

*5TONIC Laboratory, Spain*

Thursday, 21 June, 11:00-12:30, Room Linhart hall

#### Motivation and Background

The network will remain, for the next decade and beyond, the fundamental cornerstone of every Information and Communication Technology (ICT) system. Regardless of the ICT research field or application area, current, emerging or future, it is inconceivable to envision it in an isolated way. From supercomputers and parallel computers, to data analytics, passing through cybersecurity, the Internet of Things (IoT), cooperative robots, or autonomous vehicles, it is universally agreed that every system and application must be interconnected to its peers, as well as to other related entities and systems.

This implies that the network, as a universal connecting paradigm, is permanently stressed by an ever-increasing demand of stringent performance requirements, number of connected terminals, geographical coverage, energy consumption and related key performance indicators. The network model itself is challenged, evolving from the current transport-only network, into a hybrid computing/transport model, oriented to the location of content and services, or even new forms of communication paradigms, instead of the current interconnection of terminals. At the same time, there is enormous pressure from end users and operator companies alike, to reduce the CAPEX and OPEX costs while increasing all the other capabilities. One of the relevant aspects to be addressed is the security of the network operation, as an absolutely critical infrastructure, as well as privacy and auditability issues.

Smart Connectivity in the context of NGI is the crystallization of the different research elements into a network model and architecture that can address the challenges of the network-centric world. Smart Connectivity builds over the required scientific advances in the areas of physical sciences, logical sciences and key enabling technologies to provide a coherent framework supporting the future networks designs. The precise definition of Smart Connectivity will be emerging as the result of intense research in the coming years. However, we can already envision some of the characteristics of Smart Connectivity:

- Integrated Connectivity, Computing and Control (the 3Cs)
- Massive tailored services
- Converged fixed and mobile networks, integrating the 3Cs
- Support of hyperconverged overlays
- Hundreds of trillions ( $10^{14}$ ) of connected, active, devices and terminals
- High societal and vertical penetration: Energy, transport, health, entertainment, security, industry, aerospace and many other sectors

This panel will allow a passionate discussion among its invited experts over the future trends and characteristics of the Smart Connectivity concept.

## Questions

- What will be the key technological elements of Smart Connectivity?
- What will be the control and data planes of Smart Connectivity?
- What will be the radio characteristics of Smart Connectivity?
- What will be the challenges for a widespread deployment of Smart Connectivity?
- What role will European companies and academia have in the world market of Smart Connectivity?

## Participants

**Chair: Arturo Azcorra**

*Vicepresident of 5TONIC Laboratory, Spain*

**Serge Fdida**

*Sorbonne University, France*

**Diego Lopez**

*Telefonica I+D, Spain*

**Stefan Parkvall**

*Ericsson, Sweden*

**Dimitra Simeonidou**

*University of Bristol, United Kingdom*







# Workshop 1

## Vertical Industries & Services for 5G (VIS5G)

Organisers:

**Woon Hau Chin**

*Toshiba Research Europe Limited, UK*

**Erik G. Ström**

*Chalmers University of Technology, Sweden*

**Chiara Buratti**

*University of Bologna, Italy*

**Laura Baracchi**

*Trust-IT Services, UK*

**Mikael Fallgren**

*Ericsson Research, Sweden*

**Belkacem Mouhouche**

*Samsung Electronics Research, UK*

**Stephanie Parker**

*(Trust-IT Services, UK)*

Monday, 18 June 2018, 09:00-18:00, Štíh Hall

### Motivation and Background

The workshop is jointly organized by a group of projects committed to driving vertical industry adoption of 5G by promoting and nurturing research in applications of 5G communications (these projects include: 5G-Xcast (<http://5g-xcast.eu>), 5G-MEDIA (<http://www.5gmedia.eu>), SaT5G (<http://SAT5G-project.eu/>), 5GCity (<http://www.5gcity.eu>), IORL (<https://iorl.5g-ppp.eu/>), H2020 Project FLAME (<http://www.ict-flame.eu> <<http://www.ict-flame.eu>>), Clear5G (<http://clear5g.eu/>), 5GCar (<https://5gcar.eu/>), Glocal5G (<http://global5g.org/>), and IRACON (<http://www.iracon.org/>)).

The motivation will be to bring together experts on 5G to discuss the possible vertical applications of 5G as well as how the envisioned applications are growing with the development of 5G standards.

This is also a platform for different H2020 5G projects to interact and understand how the different verticals of 5G is shaping up and possibly encourage the future collaboration of the partners across different projects and sectors.

The workshop targets industries spanning Automotive, Media, Health, Energy as a pathfinder for future actions by pursuing the following goals:

- Discuss progress and priorities with participating projects.
- Gather requirements emerging from use cases that can feed into the standardisation process.
- Ensure industry views are represented, also beyond 5g PPP.
- Engage in a multi-stakeholder dialogue aimed at facilitating contributions to the standards process.

Outputs will feed into relevant WGs within the 5G PPP and the 5G-IA, such as Automotive WG, Trials WG, Pre-standardization, Spectrum. The workshop will also be the basis for a showcase of 5G advances and benefits across the verticals; demonstrating EU leadership, which will be published on the participating project websites for wider promotion.

Moreover, as part of the activities to promote research in 5G applications, the cluster of projects has plans for feature topics and special issues in journals and magazines. We plan to invite any outstanding papers submitted to this workshop to publish an extended version of those work in future special issues that we will organize.

## Structure

09:00-09:30 **Keynote 1** – Future distribution of public service media content and services’ by Darko Ratkaj (EBU, Switzerland)

09:30-10:00 **Keynote 2** – Wireless Channel Models for 5G Verticals by Claude Oestges (Université catholique de Louvain/IRACON, Belgium)

10:00-10:15 **PP1 – IORL:** A 5G Broadband Radio-Light Architecture for Media and Entertainment in Buildings by John Cosmas (Brunel University, UK)

10:15-10:30 **PP2 – 5GCity:** Transforming Cities into Hyper-Connected World, Nicola Ciulli (Nextworks, Italy)

10:30-11:00 Coffee Break

11:00-11:15 **PP3 – 5G-MEDIA:** MEDIA : Boosting the Media Industry with 5G: the 5G-MEDIA project use cases by Pasquale Andriani (Engineering Ingegneria Informatica Spa, Italy)

11:15-11:30 **PP4 – SaT5G:** SaT5G Solution for eMBB Content Delivery in 5G Using Satellite Multicast by Georgia Poziopoulou (Avanti Communications, UK)

11:30-11:45 **PP5 – FLAME:** Insights into media service delivery using real-life 5G infrastructures by Michael Boniface (IT Innovation, UK)

11:45-13:00 Panel 1 – Future Trends in Media Distribution

## Moderator:

**Andrea M. Michelozzi**  
*Comunicare Digitale, Italy*

## Panellists:

**Darko Ratkaj**  
*EBU, Switzerland*

**Adam Kapovits**  
*Eurescom, Germany*

**Dirk Trossen**  
*Interdigital, UK*

**Kumarendra Sivarajah**  
*Avanti Communications, UK*

13:00-14:00 Lunch

14:00-14:30 **Keynote 3** – 5G V2X Deployment by Mikael Fallgren (Ericsson, Sweden)

14:30-15:00 **Keynote 4** – Multi-Class Random Access Preambles for massive MTC Communications by Hsuan-Jung Su (NTU, Netherlands), Mingzoo Wu(III, Taiwan) and Shih I Chen (III, Taiwan)

15:00-15:15 **PP6** – Clear5G by Haibin Zhang (TNO, Netherlands)

15:15-15:30 **PP7 5G-Xcast:** 5G-Xcast for Public Warning Systems by David Gomez-Barquero (UPV, Spain)

15:30-16:00 Coffee Break

16:00-16:15 **PP8 – NRG-5:** 5G for Smart Energy by John Davies (British Telecom, UK) & Miha Smolnikar (JSI, Slovenia)

16:15-16:30 **PP9 – 5GCar:** Mikael Fallgren (Ericsson, Sweden)

16:30-18:00 **Panel 2** – Impact of 5G on Verticals

## Moderator:

**Erik Ström**  
*Chalmers Univ. of Technology, Sweden*

## Panellists:

**Mikael Fallgren**  
*Ericsson, Sweden*

**Ryan Chen**  
*Adlink, Taiwan*

**Leonardo Goratti**  
*CREATE-NET, Italy*

**Antonino Albanese**  
*Italtel, Italy*

**Philippe Cousin**  
*Eglobalmark, France and 5GinFIRE*

**Massimo Bertoncini**  
*Engineering, Italy and NRG5*





## Workshop 2

### From cloud ready to cloud native transformation: What it means and Why it matters

Organisers:

**Bessem Sayadi**

*Nokia Bell-Labs, France*

**Cristian Patachia**

*Orange, Romania*

Monday, 18 June 2018, 09:00-13:00, E1 Hall

#### Motivation and Background

The softwarization of the network is focused on the virtualization, decoupling the HW from the SW to lower the cost of network and service operation and to reduce the time to market for new services while introducing higher flexibility. In addition, virtualization of networking systems offers a multitude of benefits for telecommunication and datacenter operators by decoupling network functions from proprietary hardware as well as decoupling services from propriety service platforms.

In the same time, the cloud has disrupted the established order in many sectors. And the reason is simple. With it, companies have been able to reduce the investment in their internal data centers in favor of unlimited computing resources, available on demand and billed for use. From now on, the competitiveness of a company depends directly on its capacity to quickly realize new ideas. Start-ups understand this well, so they rely on native cloud approaches to disrupt traditional sectors. It becomes obvious that innovations should be made cloud-native for being successful where the functions are designed for a cloud environment rather than packaged up and deployed onto it.

Cloud-native is an approach to build and run applications that fully exploit the benefits of the cloud computing model. The Cloud-native approach is the way applications are created and deployed, not where they are executed. It includes things like services architectures, infrastructure as a code, automation, continuous integration/delivery pipelines, observability/monitoring tools, etc

A research ecosystem of horizontal and vertical R&D actions is being formed, which examines the transformation from cloud ready to cloud native in the telco world. A carrier-grade enhancement to the Telco cloud native platform are required to provide better-than-IT performance in par or better than what is possible with classical telco platforms. Features like five-nine reliability, stateless microservices, etc should be 3 / 5 supported in the Telco cloud native. A fast virtualization and programmability across all networking domains: from core to edge and access, from wired/optical to wireless, cellular and also satellite, is also considered.

The workshop is not only about 5G technologies and their implementation – with, for instance, Cloud-RAN, functional split and resource management techniques in 5G – but also about the whole service-based technology relevant to 5G in the cloud-native transformation. A service-based technology, by definition, offers hardware and/or software resources provided as a service over a network.

This open workshop aims at reinforcing this European research ecosystem by strengthening the liaison between the participating projects, facilitating the exchange of ideas and helping each research group to take advantage of the results produced by other projects, improving focus of innovation and aligning towards common goals and milestones, thus maximizing the overall impact. The Workshop will promote and stimulate the discussion about development of new research directions for building a stronger abstraction layer for the cloud, programmable infrastructure, cognitive management, flexible programmability of 5G networks services, managing application lifecycle in the cloud, etc

The workshop is endorsed by the Software Networks Working Group of the 5G-PPP (<https://5g-ppp.eu/>), and supported by participating projects and partners.

The participants will have the opportunity to exchange ideas, share hands-on experience and solutions and discuss research results. The workshop will aim in extending collaborations and paving common exploitation strategies. The structure of the workshop is based on invited presentation of H2020 projects that operate on the same focus area, followed by breakout sessions on particular subjects allowing immediate interaction between the delegates and facilitating the exchange of expertise and best practices in the field.

The workshop will invite a Keynote, from US, to talk about the cloud transformation in Telco.

## Structure

The workshop will be structured as follows:

### Session 1 (30min)

- Keynote presentation: 'Softwarization of infrastructures and virtualization: Challenges, Solutions, and Remaining hurdles from a security perspective', Marc Lacoste (ORANGE FR)
- 'From Webscale to Telco: The Cloud Native journey', Bessem Sayadi (Nokia Bell-Labs France, 5GPPP Software Network WG Chair, NGPaaS)

### Session 2 (60 min)

- 'Future network transformation. 5G cloud architectures', Marius Iordache, (ORANGE, RO, SLICENET, 15 min)
- 'NGPaaS: A cloud native solution', Bessem Sayadi (Nokia Bell-Labs France, NGPaaS, 15 min)
- 'Cloud native for vertical services', Thomas Deiss (NOKIA, DE, 5G-TRANSFORMER, 15 min)
- 'Separation of concerns among application and network services orchestration in a 5G ecosystem', Anastasios Zafeiropoulos, (Ubitech, GR, MATILDA, 20 min)

Coffee Break

### Session 3 (90 min):

- 'Platform for 5G services and functions from multiple infrastructure and service providers', Dimitrios Gkounis, (University of Bristol, UK, Metro-Haul, 15 min)
- 'SONATA 4.0 Service Platform experience in ETSI plugtests', Ricard Vilalta (CTTC, ES, 5G TANGO), 15 min
- 'Towards Using FaaS for Network Functions Virtualization', David Breitgand (IBM Research-Haifa, IL, 5G-MEDIA, 15 min)
- 'Roaming solution for multi-domain virtualized environments', Luca Cominardi, (UC3M, ES, 5GEX, 15 min)
- 'Towards SDN-based resource and mobility management in cloudified RANs', Panagiotis Demestichas and Andreas Georgakopoulos, (Incelligent, GR, 5G-PHOS, 15 min)
- 'Microservices cloud native architecture enabling 5G smart energy', Antonello Corsi, (ENG, IT, NRG5, 15 min)

### Closing panel (wrap up/potential collaborations identified/conclusions):

- Panel composed of all speakers and moderated by chairs

## Workshop 3

### 2<sup>nd</sup> Multi-provider, multi-vendor, multi- player orchestration: from distributed cloud to edge and fog environments in 5G

Organisers:

**Róbert Szabó**

*Ericsson, Sweden*

**Arturo Azcorra**

*UC3M and IMDEA Networks, Spain*

**Antonio de la Oliva**

*UC3M, Spain*

**Sergi Figuerola**

*Fundacio i2CAT, Spain*

**Jesus Gutierrez Teran**

*IHP Microelectronics, Germany*

**Roberto Bruschi**

*CNIT, Italy*

**Theo Lynn**

*DCU, Ireland*

Monday, 18 June 2018, 09:00-18:00, M3 hall

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#### Motivation and Background

Network Service Providers are limited in maximizing usage efficiency of their resources and limited in revenue generation capability from rigid service offerings which often take long to provision. A first step towards improving this situation requires mechanisms for contracting, invoking and settling for the wholesale consumption of resources and virtual network services, in a way that these services can be rapidly provisioned and invoked. Services (multi-vendor) will be programmed, as opposed to physically deployed and configured, on top of virtual resources, from multiple operators, that can now be flexibly allocated and sliced. This conglomerate of federated resources should simultaneously support an extremely diverse range of networking and computing requirements to meet the specific needs of vertical industries. Some 5G applications impose quite challenging requirements (e.g., very low latency), stressing the network and cloud infrastructures needing to relax the initial assumption of pure centralized resources, to enable resources being closer to the end users. In this scenario, to efficiently address the increasing computing requirements of 5G services, satisfying at the same time other service specific constraints such very low latency, there is a clear need for new architectural approaches for 5G. In this context, edge computing promises to enable a certain level of centralisation and, as such, efficiency gains, addressing at the same time the high bandwidth and very low latency requirements of 5G services. Edge computing is inspired by the computing cloud paradigm, but aims to minimise the service delay associated with the transportation of data through the cloud, where the distance between end devices and compute resources is large or/and the network resources are limited. To address these issues, edge computing has been proposed to deploy computing resources closer to end users. Fog and Edge computing allows end devices to perform computation offloading of their tasks to edge servers, which execute the computational tasks on behalf of the end devices.

This workshop aims at putting in common the results in the area of multi-actor orchestration, fog and edge computing, by strengthening the liaison between the participating projects, facilitating the exchange of ideas and helping each research group to take advantage of the results produced by other projects, improving focus of innovation and aligning towards common goals and milestones, thus maximising the overall impact. The workshop will provide the links between 5G-PPP phase 1 projects and new 5G-PPP projects conducting research in the areas of SDN and NFV multi-domain orchestration and federation, fog, edge and distributed cloud computing, empowering effective knowledge transfer, potent partnerships and mutual collaboration amongst them. The participants will have the opportunity to exchange ideas, share hands-on experience and solutions and discuss research results. The workshop will aim in extending collaborations and paving common exploitation strategies.



## Participating Projects:

# WS3

- 5G-Exchange: <http://www.5g-ex.eu/>
- 5G-TRANSFORMER: <http://www.5g-transformer.eu/>
- 5G-CORAL: <http://www.5g-coral.eu/>
- NECOS: <https://intrig.dca.fee.unicamp.br/necos/>
- 5G!Pagoda: <https://5g-pagoda.aalto.fi/>
- 5G-MONARCH: <https://5g-monarch.eu/>
- NG-PAAS: <http://ngpaas.eu/>
- SliceNet: <https://slicenet.eu/>
- 5GCity: <https://www.5gcity.eu/>
- 5G-PICTURE: <http://www.5g-picture-project.eu/>
- MATILDA: <http://www.matilda-5g.eu/>
- One5G: <https://one5g.eu/>
- 5GMEDIA: <http://www.5gmedia.eu/>
- RECAP: <https://recap-project.eu/>

## Structure

The workshop will be structured as follows:

### Keynote presentation (30 min).

- “The new Open Source MANO (OSM) architecture”, Diego López (Telefónica, ETSI NFV chairman).

### Session 1 (1h) of invited project presentation (4 presentations, 15min).

- “5G-TRANSFORMER: enabling multi-domain network slicing at the mobile transport for verticals”, Antonio de la Oliva (UC3M, 5G-TRANSFORMER).
- “Recursive Orchestration for Platform of Platform Approach”, Lionel Natarianni (Nokia Bell-Labs France, NGPaaS).
- “5G!Pagoda Network Slicing Reference Architecture”, Adlen Ksentini (EURECOM, 5G!Pagoda).
- “Roaming in an NFV-enabled multi-operator world”, Carlos J. Bernardos (UC3M, 5GEx).

Coffee break.

### Session 2 (1h 30 min) of invited project presentations (6 presentations, 15min).

- “Federating MEC and Telco Cloud environments for multi-domain slice provision”, Luis M. Contreras (Telefonica, NECOS).
- “5G MoNArch: providing resource elasticity through network slicing”, Albert Banchs (UC3M, 5G-Monarch).
- “Multi-domain network slicing for vertical businesses in 5G”, Qi Wang (University of the West of Scotland, SliceNet).
- “Multi-RAT convergence in 5G – A new spin through the Edge”, Alain Mourad (Interdigital, 5G-CORAL).

- “5G-CORAL Business Perspectives regarding Edge and Fog”, Chenguang Lu (EAB, 5G-CORAL).
- “Ultra-reliable communications in Factories of the Future – the Clear5G approach”, Klaus Moessner (Surrey, 5GClear project).

Lunch break.

### Session 3 (1h 30min) of invited project presentations (6 presentations, 15min).

- “Telco Grade Mobile Edge Platform”, Lionel Natarianni, Bessem Sayadi (NGPaaS).
- “Enabling Edge Computing for 5G Verticals”, Roberto Bruschi (MATILDA).
- “Edge Computing – Empowering Cities infrastructures”, Shuaib Siddiqui (5GCity).
- “HW based Offloading of Transport layer functions on SmartNICs”, Angelo Tulumello (5G-PICTURE).
- “A service platform architecture enabling programmable edge-to-cloud virtualization for the 5G Media industry”, Dr Stamatia Rizou (5G-MEDIA).
- “fog05: Converging MEC and Fog Computing”, Angelo Corsaro (5GCity).

Coffee break.

### Session 4 (30min) of invited project presentations (4 presentations, 15min).

- “Licensing and Entitlement Issues in Fog and Edge Computing – A Business Perspective”, Aidan Gallagher (InishTech).
- “Reliable Capacity Provisioning in Cloud/Edge/Fog Environments: The RECAP Approach”, Theo Lynn (DCU Business School).

**Closing panel (30min), speakers + chair.**  
**Q&A (30min).**

## Workshop 4

### 2<sup>nd</sup> Workshop on business models and techno-economic analysis for 5G networks

Organisers:

**Theodoros Rokkas**

*inCITES Consulting, Luxembourg*

**Ioannis Neokosmidis**

*inCITES Consulting, Luxembourg*

**Carmen Mas Machuca**

*Technische Universität München,  
Germany*

**Marco Di Girolamo**

*Hewlett Packard Enterprise, Italy*

**Valerio Frascolla**

*Intel, Germany*

Monday, 18 June 2018, 14:00-18:00, M4 hall

#### Motivation and Background

This workshop will focus on relevant business- and techno-economic aspects of 5G networks. It will provide insight on the business impacts and opportunities from the deployment of 5G networks for all actors in the telecommunications ecosystem such as verticals, incumbent and new operators, service providers, application developers, content providers, regulators and equipment manufacturers.

The forthcoming 5G system promises to address most of the existing limitations of current networks as well as to improve several aspects and introduce new functionalities and business models. Network softwarization, virtualization and multi-tenancy are some of the improvements associated with 5G that can create new business opportunities for traditional telecom operators and new actors such as service providers, software developers, brokers, startups and SMEs. The Workshop will address these new business opportunities and will present and debate new business models, taking into consideration potentially new stakeholders.

The workshop will also address aspects related to the techno-economic analysis of future 5G deployments such as CAPEX and OPEX modeling, demand models for new services, pricing strategies and charging schemes, including new methodologies and modeling. It will also identify major challenges of business and service coordination in the multi-actor 5G services value chain and will depict the correlation of 5G wholesale services as fundamental building blocks and enablers for retail markets and verticals.

Finally, also the important aspects of standardization status and support of the new 5G technology enablers as well as regulation matters for 5G deployments will be discussed.

The workshop will bring together representatives from the most important H2020 projects and other parties' interest in the development and progression of the identified topics.



## Structure

The workshop will be structured around the current progress and research activities of the H2020 projects in the areas of business modelling, techno-economic analysis and ecosystem impact of the newly proposed 5G technologies.

The structure of the Workshop is as follows:

*Keynote speaker (30 min):*

### **Professor Federico Pigni**

*Grenoble Ecole de Management*

## **Session 1 (1h) of invited presentations** (3 presentations 20 min each)

### **Håkon Lønsethagen**

*Telenor:*

“Multi-Provider Services and Business Enablers By The 5G Exchange Service Orchestration”

### **Carmen Mas Machuca**

*Technische Universität München:*

Techno-economic evaluation of SDN/NFV applied to Wind Parks”

### **Valerio Frascolla**

*Intel:*

Limitations and issues of 5G deployments from the standards and regulatory point of view”

Coffee break

## **Session 2 (1h20m) of invited presentations** (4 presentations 20 min each)

### **George Agapiou**

*OTE:*

“Techno-economic analysis of controller-Coherent case”

### **Simon Fletcher**

*RealWireless:*

“5G platforms for business value creation”

### **Theodoros Rokkas**

*inCITES Consulting:*

“The neutral host as a driver for future network deployments”

### **Valerio Frascolla**

*Intel:*

“Techno-economic aspects of mmWaves and MEC, two key enablers for 5G networks”

## **Closing panel and Q&A (30min)**

## **Discussion and conclusions.**

*Chair:*

### **Theodoros Rokkas**

*inCITES*

*Panellists:*

### **Håkon Lønsethagen**

*Telenor*

### **Carmen Mas Machuca**

*Technische Universität München*

### **Valerio Frascolla**

*Intel*

### **Simon Fletcher**

*RealWireless*

## Workshop 5

### Optical and Wireless Network Convergence: An Enabler for 5G

Organisers:

**Anna Tzanakaki**  
*University of Bristol, UK*

**Yi Zhang**  
*Trinity College Dublin, Ireland*

**Andrew Lord**  
*British Telecom, UK*

**George Limperopoulos**  
*COSMOTE, Greece*

**Luiz DaSilva**  
*Trinity College Dublin, Ireland*

Monday, 18 June 2018, 09:00-18:00, E2 hall

#### Motivation and Background

The current trend towards softwarization of telecommunications networks blurs the lines between domains where the different network functionalities reside. In addition to that, a key promise of 5G is to support a very diverse set of services including vertical industries, relying on a common network infrastructure that can be flexibly and efficiently shared through virtualisation. Both of these are hot topics in the telecommunications industry and academia, and can enable crossing of traditional boundaries between wireless access, optical access, metro and core networks as well as cloud computing.

This vision can be facilitated through the advent of network function virtualisation, cloud radio access networks, and software-defined networking, while it is becoming critical to bring the optical and wireless research communities together to solve problems of direct impact to fixed and mobile operators. In this context, particular emphasis needs to be given on the integration and orchestration of different access and transport technologies.

To address the large variety of 5G services, RAN deployments need to be transformed into open, scalable and dynamic ecosystems able to flexibly and efficiently support greatly varying requirements. In this context, new architectural models allow to migrate from highly distributed and inefficient structures to more centralized approaches relying on concepts such as the Cloud-RAN. Cloud-RAN and its variants including dynamic functional splits, introduce the need for fronthaul services interconnecting remote antennas with processing units to allow centralization and ultimately RAN softwarization. Through pooling and coordination gains of softwarized/centralized RANs, significant cost reductions as well as increased scalability and flexibility can be achieved. To successfully deploy the concept of softwarized RAN and support the increased backhaul requirements of 5G services, there is a need for high capacity transport networks interconnecting remote antennas with compute resources where softwarized versions of the RAN protocol stack are also executed. This will be enabled by control plane solutions that manage and optimize the operation of a large number of highly heterogeneous network and compute elements. It is therefore clear that 5G goes far beyond the definition of new RAN technologies and interfaces and is about a new end-to-end network vision, in which softwarization and virtualization allow a common network infrastructure to be flexibly used by a variety of ICT applications and a wide range of vertical industries. In this context, transport networks that can support end-to-end requirements associated with both fronthaul and backhaul services, including huge increase in capacity and connectivity and very stringent latency constraints play a key role.

This workshop is co-organized by the FUTEBOl project, a collaboration between Europe and Brazil that is enabling experimental research across optical and wireless testbeds. This workshop is also co-organized by 3 Phase II 5G PPP projects, 5G-PICTURE, Metro-Haul and 5G-PHOS, which focus on advanced 5G transport networks, exploiting optical network technologies.



This workshop will bring together researchers from industry and academia to discuss trends, challenges and opportunities for research and development of wireless/optical network convergence and transport network related challenges. Emphasis will be given on the wireless/optical network boundaries and the associated interfacing and cross-domain orchestration requirements. It will also bring together some of the main European projects dealing with issues that encompass both wireless and optical networks.

## Structure

09:00-09:15 Welcome and overview of workshop objectives  
– Anna Tzanakaki, University of Bristol, UK; Yi Zhang and Luiz DaSilva, Trinity College Dublin, Ireland

09:15-10:00 Optical and Wireless Network Convergence:  
Opening Remarks – Jorge Pereira, European Commission

10:00-10:30 “Optical X-Haul Technologies for 5G over SDN-Enabled Network” – Jim Zou, ADVA, Germany (5G-XHaul)

10:30-11:00 Coffee break

11:00-11:30 “Advanced Optical Networking: An Enabler for 5G”  
– Anna Tzanakaki, University of Bristol, UK (5G-PICTURE)

11:30-12:00 “Optical networks in a 5G world”, Luis Velasco, UPC, Spain, (Metro-Haul)

12:00-12:30 “5G mmWave networks leveraging enhanced Optical-Wireless convergence for high density environments” – George Kalfas, University of Thessaloniki, Greece (5G-PHOS)

12:30-14:00 Lunch

14:00-14:30 “Software-defined Radio (SDR) and Software-defined Network (SDN) integration for converged 5G networks” – Yi Zhang, Trinity College Dublin, Ireland (FUTEBOL)

14:30-15:00 “BlueSPACE: Analog Radio-over-Fiber Fronthaul and Optical Beamforming for Fully Converged Optical and mmW Radio Networks” – Simon Rommel, Eindhoven University of Technology, Netherlands (BlueSPACE)

15:00-15:30 “CityLab: Programmable converged networks for smart cities” – Johann Marquez Barja, University of Antwerp, Belgium (Antwerp City of Things)

15:30-16:00 Coffee break

16:00-17:00 Industry and Stakeholders Panel

**Jorge Pereira**  
*European Commission*

**Valerio Frascolla**  
*Intel, Germany*

**Paulo Marques**  
*IT Aveiro, Portugal*

**Jim Zou**  
*ADVA, Germany*

# Workshop 6

## 5<sup>th</sup> International Workshop on programmable networks: Demystifying software networks for Vertical Industries

Organisers:

**George Xilouris**  
*NCSR Demokritos, Greece*

**Josep Martrat**  
*ATOS, France*

Monday, 18 June 2018, 14:00-18:00, E1 hall

### Motivation and Background

Software networks are of key importance within the upcoming 5G networks. Technologies such as network slicing, validation and verification, monitoring and development of Vertical-oriented Network Applications are becoming of extreme importance in order to support multiple scenarios and use cases on top of the same physical infrastructure. Furthermore, various intelligent orchestration solutions are emerging, targeted at enabling the exploitation of virtual network functions and network softwarization mechanisms from vertical industries use cases.

In this workshop, special focus will be given on the usage of the proposed software network technologies by the several related vertical industries, such as smart factories, media, and smart cities.

This workshop aims at bringing together top researchers in the area of software networks under the umbrella of the EU H2020 5G-PPP projects to share their ideas and research results, and hence create an opportunity for synergy in particular with other 5GPPP and H2020 5G projects, taking advantage of the EuCNC'18 venue that acts as central hub for European research.



## Structure

The workshop will be structured as follows:

**Session 1 (30min): Keynote presentation: “Zero Touch network and Service Management” – Diego Lopez (TID) (20min) with Q&A (5min).**

### **Session 2 (65min): Technical presentations of the relevant 5G PPP projects:**

- “5G development and validation platform for global industry-specific network services and apps” – Anastasios Zafeiropoulos, Ubitech Ltd (5GTANGO)
- “Application-aware network slices: addressing DevOps requirements towards vertical applications placement over 5G infrastructure” – Panagiotis Gouvas, Ubitech Ltd (MATILDA)
- “A distributed cloud and radio platform for 5G neutral hosts” – Apostolos Papageorgiou, i2CAT (5GCITY)

## Coffee Break

### **Session 3 (65 min): Technical presentations of the relevant 5G PPP projects:**

- “5G-EmPOWER: An open OS for software defined radio access networks” – Roberto Riggio, FBK CREATE-NET (5GESSENCE)
- “5G-MEDIA: Transforming the Media Industry with 5G” – Gino Carrozzo, Nextworks (5G-MEDIA)
- “Enabling Smart Energy as a Service via 5G Mobile Network advances” – Carolina Fortuna, JSI (NRG-5)

### **Session 4 (25 min): Wrap up and conclusions.**

Session 2 & Session 3 will be by invitation. The different invited projects will need to answer some of the following technical questions:

- How does your project support 5G Network Slicing for vertical cases?
- Which are the NFV and SDN frameworks you are using in your project, and detail how you are deploying it.
- Which are your major difficulties (compatibility, stability, descriptors, packaging, etc) when deploying a multi-vendor Network Service (VNFs from several vendors) and vertical applications?
- Which is the DevOps cycle for a vertical application in your project and the offered APIs or entry points?
- What is your approach for using Catalogues of VNFs/NS (shared, custom, etc)?
- What is your strategy and implementations to include automation in the overall network management? Link to OSS.



# Workshop 7

## 3rd Network Management and QoS for 5G Networks

Organisers:

**Kieran Sullivan**

*Waterford Institute of Technology,  
Ireland*

**Anastasius Gavras**

*Eurescom GmbH, Germany*

Monday, 18 June 2018, 09:00-13:00, E3 hall

### Motivation and Background

The reason for the workshop is to show case the work of the Network Management and QoS Working Group of the EU 5G PPP.

The workshop will bring together the various contributing projects within the 5GPPP that are involved in this working group and also interested parties (projects and/or organisations) which have a common interest in the development and progression of the identified topics below:

### Network Management:

- Integration of Networking Technologies
- Integrated & Cognitive Network Management
- Virtual Network Platforms
- Multi Domain Software Networks
- Service Programmability and Orchestration
- Network Softwarisation
- Network slicing
- Intent-based management
- End-to-end service management
- Zero touch service and network management

### Quality of Service:

- Metrics, Algorithms and Techniques for QoS and QoE of the Network & Services
- SDN and NFV technologies
- ETSI OSM (Open Source MANO)
- RAN Cloudification
- Multi-Access Edge Computing (MEC)

### Network Management in the vertical industries

- Transportation/Auto-motive
- Energy
- Health
- Industry 4.0
- Public Safety
- Smart City
- Media

## Structure

The workshop will comprise:

### Opening and Introduction

**Tasos Gavras**

*Eurescom GmbH, Germany*

### Keynote (from telco industry: operator or vendor)

**Klaus Martiny**

*Deutsche Telekom, Germany*

### Functional framework for network slicing management in the 5G Radio Access Network (5G ESSENCE)

**Jordi Pérez-Romero**

*Universitat Politècnica de Catalunya, Spain*

### Machine Learning-Based Framework for Autonomous Network Management in 5G Systems (SelfNet)

**Wei Jiang**

*German Research Center for Artificial Intelligence, Germany*

### Self-Organizing Capabilities in 5G Networks: NFV & SDN Coordination in a Complex Use Case (SelfNet)

**Manuel Gil Pérez**

*University of Murcia, Spain*

### Panel session

**All presenters and keynote speaker**

### Summary and wrap-up

**Kieran Sullivan**

*Waterford Institute of Technology / Telecommunication Software and Systems Group, Ireland*

Coffee break



## Workshop 8

### Next generation network systems security

Organisers:

**Pascal Bisson**

*Thales Services, France*

**Jean Philippe Wary**

*Orange Labs, France*

**Stelios Thomopoulos**

*NCSR "Demokritos, Greece*

**Andreas Zalonis**

*NCSR "Demokritos, Greece*

**Georgios Gardikis**

*SPACE Hellas, Greece*

**Theodoros Rokkas**

*inCITES Consulting, Luxembourg*

**Ioannis Neokosmidis**

*inCITES Consulting, Luxembourg*

Monday, 18 June 2018, 14:00-18:00, E3 hall

#### Motivation and Background

The introduction of Network Function Virtualization (NFV) and Software Defined Network (SDN) technologies for the next generation telecommunication systems promises their transformation into IT like networks. This change raises concerns, as these new generation networks will become vulnerable to cyber threats and attacks that until now were only targeting IT systems and networks.

In order to secure the next generation networks a multidimensional approach is needed that will cover all parts of the ecosystem. It includes research areas such as understanding the cyber-criminal incentives along with the business models, proposing monitoring methods and tools for analysis of threats, and introducing solutions for securing the telecom infrastructure.

#### Some indicative research topics include:

- Cyber security economics and business modelling
- Monitoring methods and tools
- Legal and ethical issues
- Network security and privacy
- Security Architectures
- Security Policies
- Cyber threat intelligence

#### The purpose of the workshop is twofold:

- Present on-going work regarding next generation network systems security starting first with the work engaged within 5G PPP for what concerns 5G Security and the security of 5G Verticals, but then opening to work on-going at the level of other projects not limited to 5G in order share findings/insights but also put things back into perspective.
- Learn from invited speakers and open a discussion with relevant stakeholders to complement the findings from work done vs on-going on the field of next generation network systems security in order to further drive the Vision (5G Security & beyond) also agree on where lies the priorities for the future systems to release their full potential (also next generation networks such as 5G to make their promises)

The workshop is organized under the theme security in the track "NET – Network softwarisation", but addresses the technical topics of all the EuCNC tracks.



## Structure

The workshop will be organized as follows:

### Session 1 (90mn)

- Perspectives from 5G PPP/IA SEC WG on 5G Security Landscape (35min)
  - 5G-PPP Security Landscape and way forward (Pascal Bisson, Thales & Jean-Philippe Wary, Orange)
  - Security considerations in 5G network slicing (Prof Qi Wang, University of the West of Scotland)
  - Perspective from SAT-5G project on security of verticals (Sander)
  - Smart Energy as a Service via 5G Mobile Networks: Security Challenges and Perspectives from NRG-5 project (Wafa Ben Jaballah, Thales)
- Complementary perspectives from SHIELD & SAINT Projects (35min)
  - George Gardikis (SPACE): "SHIELD: A framework for deploying and managing virtual security infrastructures"
  - John Bothos (NSCRD): "SAINT Project – A Quantitative Approach on the Economics of Cyber-Security"
- Keynote from invited speaker (20min)
  - Diego Lopez (Telefonica): « On the Verifiability Challenges of Software Networks»

Coffee Break

### Session 2 (90mn)

- Presentations of 3 invited papers from relevant H2020 projects (50 min)
  - Edgardo Montes de Oca (Montimage): "Cyber threat detection and risk analysis of 5G networks"
  - Dimitris Kavallieros (KEMEA): "Cyber-Trust: An innovative cybersecurity platform for IoT"
  - Pedro Diogo (Ubiwhere): "Security considerations for 5G Neutral Hosts"

- A panel discussion that will conclude the workshop (40 min)

Panel on "5G Security Perspectives": bringing together representatives of large industry, vertical domains (e.g. Industry 4.0, Energy, Automotive, etc.), legislation/regulation, cyber security institution (e.g. ECSO) or government. Looking at the different perspectives the panel aims to provide feedback and additional insights to further drive 5G security, the way expected, for 5G to make all its promises and meet demands from Verticals.

*Panel Chair:*

**P. Bisson**  
Thales

*Panellists:*

**Gabriele Rizzo**  
Leonardo

**John Bothos**  
NCSR Demokritos

**Edgardo Montes de Oca**  
Montimage

**Diego Lopez**  
Telefonica





Postojna Cave, White Hall, photo [Slovenia.info](http://Slovenia.info), Miha Krivic





# Tutorial 1

## Wireless Radio Access for 5G and Beyond

Speaker:

**Huseyin Arslan**

University of South Florida, USA

Monday, 18 June 2018, 09:00-13:00, E4 hall

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### Motivation and Context

Today's wireless services and systems have come a long way since the rollout of the conventional voice-centric cellular systems. The demand for wireless access in voice and multi-media applications has increased tremendously. In addition to these, new application classes like extreme mobile broadband communication, ultra reliable and low latency communications, massive machine type communications, and Internet of Things have gained significant interest recently for 5G. The trend on the variety and the number of mobile devices along with the mobile applications will certainly continue beyond 5G, creating a wide range of technical challenges such as cost, power efficiency, spectrum efficiency, extreme reliability, low latency, robustness against diverse channel conditions, cooperative networking capability and coexistence, dynamic and flexible utilization of wireless spectrum. In order to address these technical challenges, 5G waveforms and radio access technologies (RATs) should be much more flexible. The current 4G systems rely on the orthogonal frequency multiple access (OFDM) waveform, which is not capable of supporting the diverse applications that 5G and beyond will offer. This is because the traffic generated by 5G and beyond is expected to have radically different characteristics and requirements when compared to current wireless technology. For 5G to succeed, numerous waveform alternatives have been explored to best meet its various technical requirements. However, none of the alternatives were able to address all the requirements at the same time.

During the standardization of 5G, one thing has become certain: there is no single enabling technology that can achieve all of the applications being promised by 5G networking. This will be even more pronounced beyond 5G. For this purpose, the concept of using multiple OFDM numerologies, i.e., different parameterization of OFDM based subframes, within the same frame has been proposed in 3GPP discussions for 5G. This concept will likely meet the current expectations in multiple service requirements to some extent. However, since it is almost obvious that quantity of wireless devices, applications, and heterogeneity of user requirements will keep increasing towards the next decade(s), the sufficiency of the aforementioned flexibility level remains quite disputable considering future expectations. Therefore, novel RATs facilitating much more flexibility are needed to address the aforementioned technical problems.

In this tutorial, we will discuss the potential directions to achieve further flexibility in RATs beyond 5G. In this context, a framework for developing flexible waveform, numerology, and frame design strategies will be discussed along with sample methods in this direction. We will also discuss their potential role to handle various issues in the upper system layers.



## Structure and Content

**The tentative outline of the tutorial will be as follows:**

- Channel and waveform
- Application and waveform
- Introduction to OFDM and Multi-Carrier Modulation
- OFDM advantages and problems
- Adaptive, Flexible & Cognitive OFDM
- Other Important Waveforms (SC-FDE, SC-FDMA, DFT-s-OFDM, UW-OFDM etc.)
- Numerology and OFDM (OFDM variants from OFDM baseline)
- Future concepts in Waveform:
  - mmWave waveform design (SC versus MC in mmWave)
  - Hybrid waveforms
  - Flexible waveforms
  - Non-orthogonal waveform design
  - Differential modulation (non-coherent modulation) in OFDM (minimal pilot OFDM design)
  - PHY security in OFDM (secure OFDM design)

## Level/Pre-requisites

This tutorial is intended for technical professionals in the communications industry, technical managers, and researchers in both academia and industry. Therefore, the key audience for the tutorial is: graduate students (Master or PhD), postdoctoral scholars, researchers, faculty members, scientists, and engineers in academia as well as in the public and private sectors in the broad area of wireless telecommunications.



## Tutorial 2

### Vertical-Oriented End-to-End Orchestration in 5G Networks: Modeling, Optimization, Implementation, and Verification

Speakers:

**Vincenzo Sciancalepore**

NEC Laboratories Europe GmbH,  
Germany

**Mérouane Debbah**

Huawei Technologies, France

**Alessio Zappone**

CNRS, France

**Marco Di Renzo**

CNRS, France

Monday, 18 June 2018, 14:00-18:00, E4 hall

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#### Motivation and Context

The massive deployment of “smart” devices, broadband and mission critical services along with a huge variety of scenarios, ranging from smart city to broadband media are paving the way for a novel and disruptive 5G communication network that will enable massive capacity, zero delay, faster service development, flexibility, elasticity and optimal deployment, less energy consumption, enhanced security, privacy by design, and connectivity to billions of devices with less predictable traffic patterns. Accordingly, next-generation networks need to be capable of handling a complex context of operations and support an increasingly diverse set of new and yet unforeseen services, whose extremely diverging requirements will significantly boost mobile network performance and capabilities.

Additionally, next-generation networks need to provide flexible, smart and scalable adaptation and/or association of the available network resources to the specific requirements of the supported services, enabling a dramatic paradigm shift from the CAPEX to the OPEX “Everything-as-a-Service” driven business models

To meet the 5G challenges, the ICT industry has moved fast, developing a number of breakthrough innovations. Multiple vendors from all over the world bring the new technology into the market even though most of the products are still in the development phase, whereas a global consensus is progressing slowly on how 5G will proceed with respect to technological barriers, regulatory restrictions and standardization activities. It is clear that 5G networks will not be based on a single specific technology, but they will be considered as a portfolio of access, connectivity and flexibility solutions addressing the demands and requirements of mobile communications beyond 2020. In order to cover the requirements from different application domains, technologies promoted in the 5G landscape range from advances on the radio access network, such as ultra-lean radio access design, device-to-device communications, MIMO antennas, along with the benefits of slicing management.

In parallel to 5G networks evolution, there are application verticals that demand specific and contradicting characteristics. According to the 5G Manifesto, 11 industry segments are considered as first-class citizens for early experimentation and large-scale demonstration for European industry and society. However, different verticals have different levels of readiness and interest for 5G adoption. With the proliferation of smart devices, the Media vertical transforms and more users are switching from the traditional linear broadcasting services (TV channels) to OTT (Over The Top) streaming services, provided by traditional broadcasting companies (e.g., Catch-up TV services) or by global companies (i.e., Apple, Amazon, Google, Netflix, etc.); the video quality increases (i.e. 3D, UHD/4K/8K/12K, Augmented and Virtual Reality (VR), etc. ), which can be translated to increased bandwidth requirements for both the core and access networks.

Finally, cloud services allow each individual user to easily create video content, store it and share it through various social network platforms. Technological advances, political visions and market liberation are transforming the Energy vertical from a closed, monolithic and highly predictable infrastructure to an open, multi-owned, decentralized ecosystem, able to support Smart Grid mission critical applications (such as fault localization, isolation/self-healing and energy re-routing), massive IoT smart metering applications requesting more stringent capacity and privacy, along with smart Electrical Vehicles (EV) charging, posing huge challenges, both in functional (i.e. stability, resiliency and highly availability) and in non-functional (i.e. security, privacy and CAPEX/OPEX) directions.

This emerging ecosystem of vertical-oriented design of 5G networks is little understood in academia and industry, and, to the best of our knowledge, there is a fundamental lack of approaches for modeling and optimizing it with focus on the diverse requirements of different vertical markets. This tutorial aims at filling this gap, describing in detail the enabling techniques to allow multiple vertical-oriented services to coexist by sharing the same physical infrastructure.

## Structure and Content

The tutorial is organized in four main parts that are described as follows.

### Introduction.

The tutorial will provide a brief introduction of the problem of vertical-oriented orchestration design of 5G networks, motivating its relevance for future wireless communications. 5G networks are expected to provide great support to the operation and management of 5G end-to-end heterogeneous facilities enabling advanced 5G services development, easier, safer and more secure testing and verification from an operational and financial point of view. In addition, the orchestration solution will orchestrate different heterogeneous 5G network facilities able to provide highly available services, to support multi-tenancy, to manage homogeneously virtualized multi-homed, static or moving, hardware constrained (smart energy, media and transport) devices, to integrate multiple RAN technologies, to manage edge computing resources and to manage virtualized services in an elastic way for the needs of media, smart city and energy vertical scenarios.

This part of the tutorial will describe the virtualization issues of Smart Energy, Virtual & Augment Reality (VAR) and Smart City use cases, covering Enhanced (or Extreme) Mobile Broadband (eMBB), Ultra-reliable

and Low Latency Communications (URLLC) and Massive Machine Type Communications (mMTC) as defined by 5GPPP and ITU. These evolving networking requirements raise critical challenges that urge for 5G physical networks (ranging from RAN to Core Network and slicing requirements [1]) along with 5G softwarization, virtualization and Management and Network Orchestration (MANO) requirements, which in turn, can be translated as facilities requirements for i) multi-tenancy that considers the ability to be open, avoid vendors' lock-in strategies, combine resources from different operators and offer connectivity services to multiple tenants, ii) flexibility, multi-domain and easy-to-use nature in order to dynamically configure the infrastructure in time and space to accommodate innovative foreseen and unforeseen 5G vertical services, iii) high availability to support via network slicing mission critical applications in the area of energy and city transportation.

### Network Virtualization and Programmability.

Network virtualization has led to significant benefits in terms of business support, service innovation, infrastructure and operational cost reduction but at the same time, it has brought significant technical challenges. The network virtualization paradigm revolutionizes networking and service experience, by abstracting and separating logical network behaviors from the underlying physical network resources.

This significantly impacts on the reduction of the capital and operations expenditures, while also driving programmability and automation of network facilities in order to enable a broad range of business services. Network virtualization elevates the traditional monolithic network design into a flexible “network of functions” following the virtual network function paradigm raising several technical challenges.

In this part of the tutorial, we will focus on the pivotal aspect of the network virtualization, i.e., the newly evolved concept of network slicing [2] that paves the road towards an automatic and flexible solution in charge of allocating a specific amount of isolated and/or shared network resources, tailored for particular vertical-oriented service requirements [3]. Network resources are meant as computing and storage capacity, virtualized network functions, physical radio resources, core network functions and backhaul/backbone connectivity. The technical challenges also stretch on the entire lifecycle process, including network slice instantiation and maintenance [4], orchestration and allocation of shared and isolated resources [5], including also communication interfaces amongst different network slices. Finally, we will analyse the implementation details of first network slicing proof-of-concept (PoC) by shedding the light on advantages and drawbacks of implementing such a novel concept on 3GPP-compliant equipment [6].

### **Network Optimization.**

This part of the tutorial addresses the issue of network optimization. Specifically, the tutorial will show how to design the system radio resources in order to optimize key performance indicators of 5G networks, including spectral efficiency, energy efficiency, end-to-end latency, etc, while at the same time guaranteeing the desired quality of service of different vertical services sharing the same physical resources, which in turn translates into the desired quality-of-experience for the network end-users. The resulting problems are highly non-convex and require specific optimization approaches beyond the traditional convex optimization framework. We will introduce the frameworks of multiobjective optimization, sequential optimization, fractional optimization, monotonic optimization, which together enable the best trade-off between global performance and computational complexity, while at the same time guaranteeing the individual performance of co-existing vertical sectors. In particular,

- Multi-objective optimization enables flexible trade-offs between individual (at a user-level and/or tenant-level) service requirements [7].
- Sequential optimization has been recently shown to achieve near-optimal performance in interference-limited networks, while requiring affordable complexity [8].
- Fractional programming has emerged as the most suited tool for the optimization of the bit-per-Joule energy efficiency of a wireless network [9].
- Monotonic optimization enables the development of lower-complexity off-line globally-optimal solution to benchmark the performance of online optimization tools [10].

This part of the tutorial provides the audience with a solid background on the above-mentioned optimization frameworks, enabling the audience to formulate and solve practical optimization problems for vertical-oriented 5G network design. Both centralized and distributed designs will be developed, discussing the resulting complexity-performance trade-off.

### **Network Modeling.**

To quantify the potential gains of vertical-oriented network modeling and design a critical role is played by the characterization of the spatial distribution of user and infrastructure locations in a network, which critically affects the quality-of-service and quality-of-experience that can be guaranteed to each user. In this context, the theory of point processes and stochastic geometry constitute an essential mathematical tool, as it provides us with general and accurate methods for modeling random spatial patterns.

This part of the tutorial provides the audience with a solid background and comprehensive description of stochastic geometry modeling, by introducing key theorems, by explaining how to formulate problems from the standpoint of system-level analysis and optimization, with major focus on illustrating how to use stochastic geometry to model vertical-oriented 5G networks. In addition to the basic theory, several new methodologies for system-level modeling are illustrated, which include the equivalent-in-distribution approach for error probability computation [11], the moment generating function for area spectral efficiency computation [12], and the intensity-matching approach for quantifying the trade-offs in terms of achievable rate and harvested energy [13]. As far as system-level optimization is concerned, a new



definition of coverage probability and spectral efficiency will be introduced and shown with several examples to constitute a tractable approach for the optimization of vertical-oriented large-scale wireless networks [14]. Finally, the suitability of stochastic geometry for wireless networks modeling is substantiated with the aid of experimental data for the locations of cellular base station and for the footprints of buildings, which are taken from two publicly available databases from the UK (OFCOM and Ordnance Survey) [15]. With the aid of several examples, we show how the proposed approach constitutes a holistic framework towards the design of vertical-oriented 5G wireless networks.

The tutorial ends with an open discussion of the latest research directions and open issues that in our opinion represent the most important challenges that need to be addressed and solved, aiming towards the successful design of vertical-oriented 5G networks.

### **Level/Pre-requisites**

Students, academic researchers, industry affiliates and individuals working for government, military, science and technology institutions who are interested in studying emerging large-scale and distributed 5G communication networks and in understanding how to model and optimize candidate network architectures, transmission technologies and communication protocols towards their self-sustained and vertical-oriented operation. The present tutorial is intended to provide the audience with a complete overview of the potential benefits, research challenges, implementation efforts and applications of technologies and protocols towards vertical-oriented communications, as well as the mathematical tools for their modeling, analysis and optimization. This tutorial is unique of its kind, as it tackles both system-level modeling and optimization aspects, which are usually treated independently. Therefore, the audience will receive a unique training experience.



## Tutorial 3

### Wireless Community networks and 5G: the 7-Billion-user challenge

Speaker:

#### **Merkourios Karaliopoulos**

Athens University of Economics and Business, Greece

#### **Iordanis Koutsopoulos**

Athens University of Economics and Business, Greece

#### **Renato Lo Cigno**

University of Trento, Italy

#### **Leonardo Maccari**

University of Trento, Italy

#### **Leandro Navarro**

Universitat Politècnica de Catalunya, Spain

Monday, 18 June 2018, 09:00-13:00, M4 hall

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#### **Motivation and Context**

As the 5G vision gets unfolded and the requirements of its ambitious key performance indicators are better understood, it also becomes clearer that there will not be a single realization path for this vision. Large parts of the worldwide population, including those living in rural areas of developed countries and those in developing regions will probably not be served by ultra-dense networks and super-fast radio links. This tutorial aims to delineate the role that community networks emerging out of citizens' grassroots activities could play in the realization of the 5G vision. It summarizes state-of-the-art practices and experience with their use, and it outlines technical research problems and outstanding challenges for their adoption. Thus, it essentially lays out elements of a complementary research agenda that so far has not attracted the proper attention from the research community. The main motivations for this tutorial are:

- Recent advances in community networks, both on the technological but also their strategic and organizational form
- Ongoing discussions and research efforts on realizing the ambitious 5G vision so that will not further amplify the digital divide worldwide
- The equally ambitious EU agendas (EU2020, EU2025) for broadband connectivity across Europe and the therein identified potential role of grassroots- and locally-driven network infrastructures.

The objectives are summarized as follows:

- Review recent advances and trends in the multifaceted area of Community Networks, in terms of technologies and strategies, as these emerge throughout the world
- Summarize the difficulties that stand on the way to delivering the 5G vision to several areas across the world and detail how Community Networking initiatives could contribute to coping with them
- Identify the research challenges that need to be tackled so that Community Networks can play an active role to this end
- Outline actions to be taken at policy-making and regulatory level to enable this role

## Structure and Content

The proposed tutorial is structured into three sessions, each one covering a particular theme. The three sessions (S1-S3) and their content are:

### S1. 5G implementation paths and Community Networks: a review of current state of affairs

This session reviews the evolution of the 5G vision, dominant approaches to its implementation, and concerns about them. It then proceeds to give an overview of the advances in Community Networks (CNs) over the last 15 years on the technological and organizational fronts. Finally, it describes how these networks could support or constitute sustainable paths towards the next generation of wireless connectivity in many areas around the globe. The session includes:

- A discussion of the 5G vision, the dominant approaches proposed for its implementation, and main challenges faced by them
- A review of CNs across the globe: technologies, organizational models, financing, together with case studies such as guifi.net, Sarantaporo.gr, and others
- CNs as alternative paths to realizing network access visions

### S2. Edge computing in CNs

Some of the research challenges in CNs are similar to what 5G networks face, in particular, distributing data processing, computation, and storage in the edge of the network in order to have smaller delays and reduce the load on the backhaul. This session will treat two research threads that try to tackle these issues with a P2P approach, relying on the openness of the network and without sacrificing Network Neutrality. These threads are,

- Distributed cloud platforms in CNs and service placement issues,
- P2P streaming in CNs

### S3. Economic sustainability in CNs and incentives for participation

This session will focus on the ways CNs pursue their sustainability so far, and new approaches that have recently emerged to this end, involving synergies with commercial service providers. It will review game-theoretic tools that help analyze and optimize these sustainability models. The session covers:

- Basic elements of behavioral economics and game theory and its use in CNs
- Economics of Infrastructure sharing: cost sharing and pricing models, and related research issues in CNs

- Incentive mechanisms for different stakeholders in CNs: theory, models and research issues in CNs: incentives for users, service providers, infrastructure providers etc
- Use of blockchaining technologies–the case of AMMBR
- Synergistic models with commercial service providers

The estimated sessions' durations and the names of instructors in each session are:

- S1: Dr. Leandro Navarro (Universitat Politècnica de Catalunya, Spain) – 45mins
- S2: Dr. Leonardo Maccari and Dr. Renato Lo Cigno (University of Trento, Italy) – 45mins
- S3: Dr. Merkouris Karaliopoulos and Dr. Iordanis Koutsopoulos (Athens University of Economics and Business, Greece) – 90mins

## Remarks

a) The assumption in the schedule is that the overall duration of the tutorial is 3hrs (2 parts of 1.5 hr each, 9-10.30, 10.45-12.15) with a 15-min break between them. Hence, the first two sessions will occupy the first part of the tutorial (9-10.30) and the third part will take place in the 2nd part.

b) All five instructors are collaborating in the content of the EU R&D project netCommons (<https://www.netcommons.eu>). Most of the tutorial's material is the outcome of their research collaboration in the context of this project.

## Level/Pre-requisites

The proposed tutorial is intended for a broad audience including:

- Graduate students and researchers in the area of wireless networks and network economics
- Practitioners in the area of mobile cellular networks
- Members of community networking initiatives
- Interested relevant stakeholders such as Telecom operators, Mobile Virtual Network Operators (MVNOs) and Service Providers (SPs)

Session 1 does not require any technical background, while session 2 requires a basic understanding of distributed systems, and session 3 requires basics of calculus and some optimization theory. However, since the researchers and practitioners that work in the field of Wireless Community Networks have diverse profiles, the aim of the tutorial is to introduce the field and its technical challenges from first principles to a broader audience.

# CLOSING SESSION

Thursday, June 21 2018, 12:30 – 13:30, Linhart hall

Speakers:

## **Narcis Cardona**

*EuCNC 2019 Host and TPC Chair*



## **EuCNC 2019**

MsC (1990), PhD (1995), Prof.(2001). Since October 1990 he is with the Communications Department of the Polytechnic University of Valencia (UPV), currently Full Professor on Signal Theory and Communications. Prof. Cardona is Director of the Research Institute of Telecommunications and Multimedia Applications (iTEAM), with 165 researchers including assistant professors & research fellows. Additionally, he is the Director of the Mobile Communications Master Degree (since 2006). Prof. Cardona has led National and European research projects, Networks of Excellence and other research forums in FP6, FP7 and H2020, always in Mobile Communications aspects. At European scale, he has been Chairman of the EU Action COST IC1004 (2011-2015), Vice-Chairman of the Actions COST273 (2003-2006) and COST IC15104 IRACON (2016- ), Chairman of the National Network of Excellence ARCO5G (2015-2016), and member of the Steering Board of METIS (7FP; 2011-2015), METIS2 (H2020 5GPPP; 2015-2017), WIBEC (H2020 ITN; 2016-2019) and PI of WAVECOMBE (H2020 ITN; 2017-2021). He has organised and participated to the Committees of international conferences, being General Chair of IEEE ISWCS 2006, IEEE PIMRC 2016, and EuCNC 2019, and TPC Chair of IEEE VTC 2015, among others. His current research topics are Radio wave propagation, Planning and Optimisation of Mobile Access Networks, Digital Multimedia Broadcasting, Dynamic Spectrum Management and Wireless Body Environment Communications.

## **Jean-Pierre Bienaimé**

*Secretary General, 5G Infrastructure Association (5G-IA)*



## **Status update on the 5GPPP Collaboration and moving ahead**

Jean-Pierre Bienaimé has been Secretary General of the 5G Infrastructure Association (5G-IA), representing the digital & telecommunications industry (operators, manufacturers, research and academic institutes, verticals, SMEs) in the Public-Private Partnership (5G PPP) with the European Commission, since 2016. He is also Chairman of the 5G PPP Steering Board. Joining France Telecom (FT) in 1979, Bienaimé has had responsibilities including Director Planning Department at FT, Advisor to the General Director of Moroccan Telecommunications in Rabat, Director of Marketing and Product Development for International Business Networks & Services at FT, Chief Executive Officer of Nexus International, and Vice-President International Mobile Support for Orange Group. From 2009 until 2016, Jean-Pierre has been Senior Vice-President Wholesale Strategy, Communications and Community at Orange. Jean-Pierre has been Chairman of mobile industry association The UMTS Forum from 2003 until 2016, with a mission to promote a common vision of the development of 3G UMTS and 4G LTE and evolutions, and to ensure their worldwide commercial success. Jean-Pierre is the chairman of IREST (Economic and Social Research Institute on Telecommunications), a think tank of influence based in Paris. Jean-Pierre is graduated from ESSEC Business School, from Institut d'Etudes Politiques de Paris, from Ecole Nationale Supérieure des Postes & Télécommunications – Paris, and from INSEAD.



**Peter Stuckmann**

*Head of Unit – Future Connectivity  
Systems DG CONNECT, EC*



## Key event takeaways and next steps of the connectivity research and policy roadmap

Peter is managing the Commission's policy on 5G communication systems and the related research and innovation programme. Before his appointment as Head of Unit he was managing the office of the Director General of DG CONNECT, Roberto Viola, coordinating the Commission's digital policy initiatives. The portfolio included Digital Single Market, Broadband Policy, Telecoms, Media and Online Policy, the Copyright Reform as well as the EU ICT Research and Innovation Programme. Between 2010 and 2014 he was Head of Sector "Spectrum Policy", was penholder of main elements of the Commission proposal on the Telecom Single Market and the Roaming regulation, and was responsible for the implementation of the EU telecom rules in Germany and Austria. Between 2005 and 2010 he coordinated the EU R&D programme leading to the 4G mobile communications standards. Before joining the European Commission in 2004 he has occupied several engineering and management positions in industry, academia and start-ups. He holds engineering and doctoral degrees from RWTH Aachen University, Germany.





18 - 21 June 2019

[www.eucnc.eu](http://www.eucnc.eu)



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EuCNC 2019 is the 28<sup>th</sup> edition of a successful series of a conference in telecommunications, sponsored by the IEEE Communications Society and the European Association for Signal Processing, and supported by the European Commission. The conference focuses on various aspects of 5G communications systems and networks, including cloud and virtualisation solutions, management technologies, and vertical application areas. It targets to bring together researchers from all over the world to present the latest research results, and it is one of the main venues for demonstrating the results of research projects, especially from R&D programmes co-financed by the European Commission. EuCNC 2019 will be co-located with the Global 5G Event, which brings together the world 5G industrial associations: 5G-IA, IMT-2020, 5G-Forum, 5G-MF, 5G-Brasil and 5G-Americas.

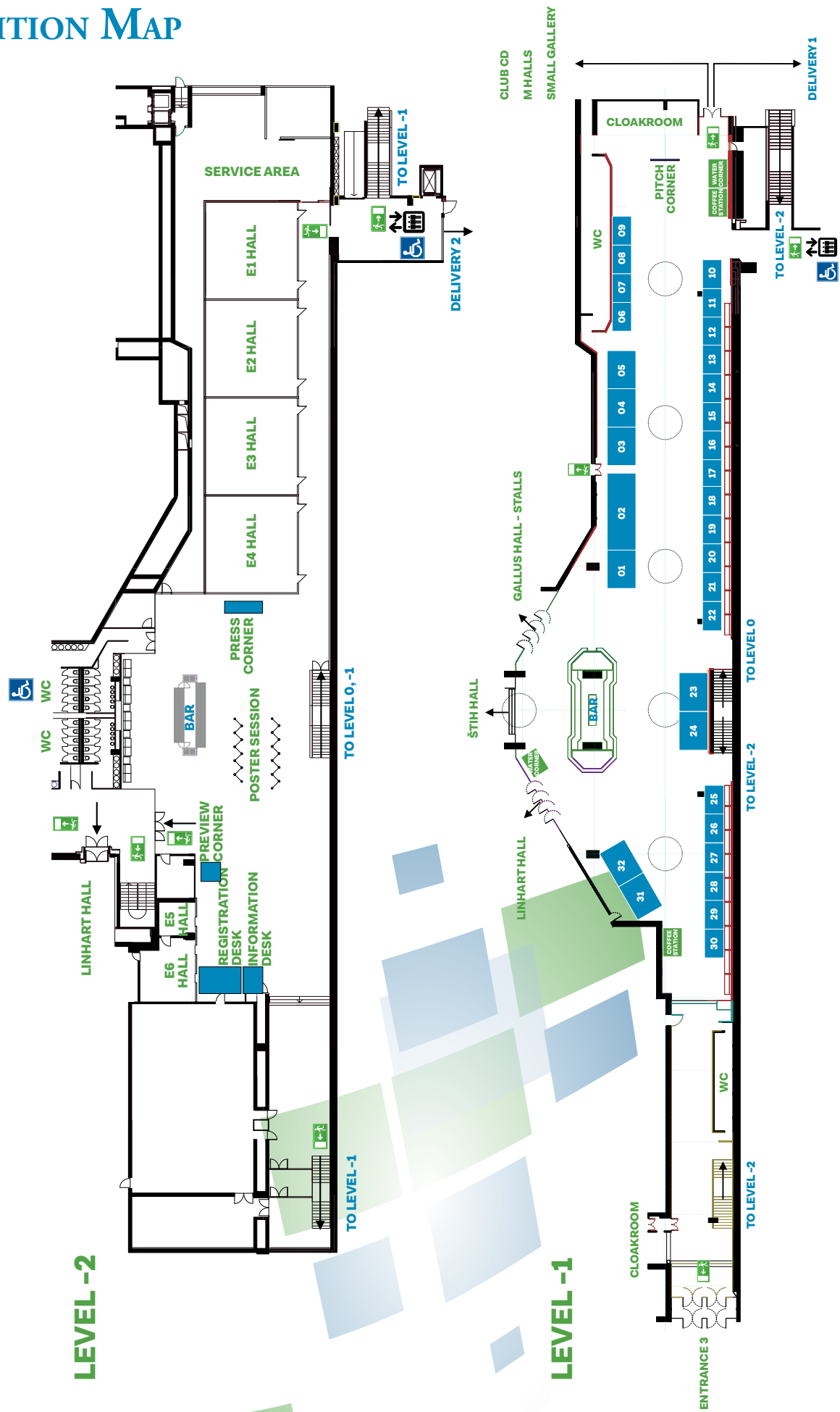
The conference program will include:

- Keynotes
- Panels
- Regular oral sessions (papers from open call, to be submitted for uploading to IEEE Xplore)
- Special sessions, with papers on specific topics
- Workshops, with papers and presentations on specific topics
- Poster sessions (papers from open call addressing latest results)
- Tutorials
- Demos and exhibitions, with pitches.

Key dates:

- 08 Feb. 2019 – Deadline for submission of papers for regular oral sessions
- 08 Feb. 2019 – Deadline for submission of proposals for workshops, special sessions, and tutorials
- 22 Mar. 2019 – Notification of acceptance of workshops, special sessions, and tutorials
- 15 Mar. 2019 – Deadline for submission of extended abstracts for posters
- 12 Apr. 2019 – Deadline for submission of proposals for exhibitions
- 15 Apr. 2019 – Notification of acceptance of papers and extended abstracts
- 26 Apr. 2019 – Deadline for final papers for all sessions and workshops
- 26 Apr. 2019 – Deadline for authors registration
- 10 May 2019 – Draft program available

# EXHIBITION MAP



# EXHIBITION AND DEMOS

## Booth #1



## ONE5G

### ONE5G – E2E-aware Optimizations and advancements for Network Edge of 5G New Radio

ONE5G is a European project which aims at providing technical investigations and recommendations beyond Release 15, moving „5G“ to “5G advanced”. The objective of the demo is to offer an overview of ONE5G prototyping activities related to factory of the future, enhanced network management, smart city, automotive, critical infrastructure and agricultural use cases.

The demo will showcase the project advancements in areas including: a) small cells multi-connectivity for reliability enhancement in industrial environments; b) advanced link enhancements based on massive MIMO as enablers for smart city applications; c) E2E monitoring schemes based on the actual user quality of experience (QoE) as enablers for the future network management solutions and; d) IoT and big data technologies for supporting critical infrastructure and agricultural use case in underserved areas and; e) video feeds from real trials of cloud robot and tele-operated driving scenarios.

The demonstration aims at: a) showing the validity, the feasibility and the superiority of the different ONE5G components; b) demonstrating the linkage of the prototyping activities with the related verticals; c) showcasing the estimated gains from their adoption in specific verticals; d) demonstrate first real trials.

## Booth #2



## 5G-TRANSFORMER, 5Gex and 5G-CORAL

This exhibition shows demos from 3 different projects that are collaborating together in the area of multi-domain, multi-provider orchestration of services and resources in cloud, edge and fog environments: 5Gex, 5G-TRANSFORMER and 5G-CORAL.

The 5Gex project is creating an agile exchange mechanism for contracting, invoking and settling for the wholesale consumption of resources and virtual network services, which can be provisioned in less than 90 minutes and rapidly invoked. This will enable network operators, applications providers and other stakeholders in the 5G supply chain to deliver new service value for 5G customers and at the same creating and enhancing revenue-generating potential for 5G providers, third party verticals and others in the supply chain.

The 5G-TRANSFORMER project aims to transform today's mobile transport network into an SDN/NFV-based Mobile Transport and Computing Platform (MTP), which brings the “Network Slicing” paradigm into mobile transport networks by provisioning and managing MTP slices tailored to the specific needs of vertical industries.

The 5G-CORAL project leverages on the pervasiveness of edge and fog computing in the Radio Access Network (RAN) to create a unique opportunity for access convergence. This is envisioned by the means of an integrated and virtualised networking and computing solution where virtualised functions, context-aware services, and user and third-party applications are blended together to offer enhanced connectivity and better quality of experience.



The following demos will be shown:

New virtualization-based roaming solution for multi-domain environments.

Video solution for emergency situations enabling assured connectivity on demand.

Dynamic media service deployment on the top of heterogeneous infrastructure combined from public and private clouds.

Dynamic service request from a vertical, transparently translated to services with different resource requirements, which are the ones finally instantiated.

RNIS MEC LTE, where we demonstrate an LTE network where a robot equipped with an LTE interface is attached to an OpenAirInterface eNodeB and EPC.

-Cloud robotics, showing multiple cooperating robots that require synchronization for accomplishing a common task. This coordination is achieved via an edge-fog system.

### Booth #3

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## ORCA

### **ORCA – Real-time software defined radio (SDR) platforms for advanced wireless research**

At EuCNC 2018 we plan to showcase the potential of state-of-the-art software defined radio (SDR) platforms for fast prototyping of 5G and beyond 5G wireless solutions. The main target of the ORCA project is to enable end-to-end networking experiments involving real-time SDR dealing with very diverse QoS requirements (in terms of throughput, data volumes, latency, response time, reliability, availability, etc.) sharing the same wireless technologies, infrastructures and/or spectral bands. To this end ORCA offers open mature, real-time and versatile SDR platforms in several wireless test facilities, supporting heterogeneous technologies and advanced control mechanisms that can cope with extreme (ultra-low latency, ultra-high throughput, ultra-high reliability) and diverging (low AND high data rate, time-critical AND non-time critical) communication needs.

We plan to show two demos, a first demo focussing on low-latency industrial communication, and a second demo on interworking and aggregation of multiple radio access technologies (RAT).



## WiSHFUL

### WiSHFUL – Wireless Software and Hardware platforms for Flexible and Unified radio and network control

We aim to present a final project demonstrator of WiSHFUL that will prove that real runtime coexistence/cooperation of deployed wireless heterogeneous networks, even from different operators and vendors, can be achieved by using the WiSHFUL intelligent software control and management framework across a wide range of networking technologies. We shall demonstrate that this is achieved with minimum effort and complexity by using WiSHFUL Unified Programming Interfaces (UPIs) to control the deployed devices during runtime. UPIs are abstracting programming interfaces that can enable transparent and unified control over a wide list of supported devices.

There is no need for the user of WiSHFUL to dig into the specifications of each deployed device to figure out which type of control is supported, as WiSHFUL exposes a wide list of control knobs across the network stack through UPIs. Another objective of our demonstration will be to prove the applicability of the Portable Testbed, a replication of a typical fixed testbed that is able to be transferred and deployed in any location, in supporting deployment of multiple heterogeneous networks in scale, comparable to what fixed testbeds can provide.



## eWINE

The eWINE project comprises of three showcases, which target a variety of research challenges from various perspectives including end-to-end wireless connectivity, elastic resource sharing in dense heterogeneous environments, and reconfigurable context based physical layer. The exhibition is about the demonstration of the showcases, where we solicit three integrated demos (one for each showcase) and each demo encompasses and validates the vision of the showcase.

**Demonstration 1:** In this demo, a basic end-to-end service in a dense wireless scenario using a centralized end-to-end controller running a cognitive loop is presented. Specifically, an integrated end-to-end demonstration is realized by providing an end-to-end connectivity to WiFi, LTE device to device communication, and IOT gateway.

**Demonstration 2:** In this demo, two independent cognitive loops named inter-technology optimization loop and intra-technology optimization loop are demonstrated for providing an optimization solution for the LPWA technologies including Sigfox, LoRA, and IEEE802.15.4g (subGHz). In the first loop, a spectrum manager based approach is used for minimizing the impact of interference among the technologies and thus, improving the performance. In the second loop, an optimization of the sigfox network is presented via blacklisting the interfering channels in the presence of interference sources.

**Demonstration 3:** In this demo, an integration of multi-RAT transceiver having various objectives such as sensing and synchronizing LTE-U signals for exploiting used spectrum portions, establishing cross-technology control channel, GFDM per frame, etc is presented.



## 5GCity

### 5GCity – Empowering Cities 5G Use Cases / Trials

The 5GCity project aims to develop a distributed cloud and radio platform for municipalities and infrastructure owners acting as 5G neutral hosts. To achieve this, 5GCity platform extends the cloud model to the extreme edge and enables scalable edge management and orchestration. Apart from this, 5GCity also focuses on MEC node virtualization, guest optimizations and network virtualization at the edge to fulfil technical requirements for a 5G neutral host. The motivation for demonstrations at EuCNC 2018 is to show case the technical developments at different fronts in the project at the end of first year of its execution. 5GCity will demonstrate, 1) 5GCity Neutral Hosting (Multi-tenancy), 2) 5GCity Guest Optimization, and 5GCity Edge Orchestrator & VIM.



## 5G-Xcast

### FUTURE5G – Future 5G-XCast production with dynamic spectrum sharing on 2.3 GHz band

5G-XCast provides means to deliver the new audio-visual media, like 4k/8k Ultra-High-Definition Television and Virtual Reality including their consumer interactivity. As a part of media production, wireless links are used between the camera and the Outdoor Broadcasting van or another type of video processing unit. The new audio-visual content requires higher bitrates and more spectrum from the wireless links than the High Definition (HD) video. At the same time, conventional PMSE link bands get other spectrum users. PMSE differs from many other types of spectrum use as being local and having a short time duration.

We demonstrate solutions how PMSE spectrum use can continue in the current form and how it can take the advantage of 5G.



## 5GCAR

Intermediate results from the 5GCAR project will be demonstrated. Background on key performance indicators, use cases and their requirements. Learnings from the studies on V2X business and spectrum aspects. Highlight of promising V2X cellular and sidelink technology components as well as intermediate V2X architecture findings, together with demonstration work and dissemination activities. To illustrate the ongoing demonstration work, a small-scale demonstrator of the Cooperative Perception for Maneuvers of Connected Vehicles use case is brought to the EuCNC booth and demonstrated here.

The demo consists of some high-level posters as well as more detailed public reports (known as deliverables) on the intermediate results from the 5GCAR project. Flyers and Brochures will be provided to convey a summary of the overall project objectives and goals. The demo also contains a small-scale demonstration, scaled replica of the actual demonstration, with robot-vehicles driving on a table to illustrate aspects of the Cooperative Perception for Maneuvers of Connected Vehicles use case.



## COST Association

COST is an EU-funded programme that enables researchers to set up their interdisciplinary research networks in Europe and beyond. We provide funds for organising conferences, meetings, training schools, short scientific exchanges or other networking activities in a wide range of scientific topics. By creating open spaces where people and ideas can grow, we unlock the full potential of science.

COST is the longest-running European framework supporting transnational cooperation among researchers, engineers and scholars across Europe. It is a unique means for them to jointly develop their own ideas and new initiatives across all fields in science and technology, including social sciences and humanities, through pan-European networking of nationally funded research activities. Based on a European intergovernmental framework for cooperation in science and technology, COST has been contributing - since its creation in 1971 - to closing the gap between science, policy makers and society throughout Europe and beyond. As a precursor of advanced multidisciplinary research, COST plays a very important role in building a European Research Area (ERA).

It anticipates and complements the activities of the EU Framework Programmes, constituting a “bridge” towards the scientific communities of COST Inclusiveness Target Countries. It also increases the mobility of researchers across Europe and fosters the establishment of scientific excellence.



## Fed4FIRE+

### **Fed4FIRE+ - Federating testbeds for 5G, IoT, cloud, big data and networking research**

A variety of testbeds for (real life) experimentation and testing exist in Europe. Even a lot of them allow open access, but the problem is that the learning curve for using them is typically too steep. Fed4FIRE, as largest federation of testbeds in Europe, helps in this by having simple tools and a single account to access all those testbeds, allowing to do experiments in the fields of 5G, IoT, cloud, big data and networking and even combining them easily. At EuCNC we want to showcase how simple it is to use the testbeds and to combine multiple testbeds in a larger experiment.

Demo 1: “5G network end-to-end cellular virtualized infrastructure provisioning” NITOS testbed is providing state-of-the-art equipment for 5G experimentation. In this demo, we will showcase how the FIRE infrastructure available in the NITOS testbed can be managed through a 5G end-to-end service orchestrator, in order to provision heterogeneous wireless network connectivity in a single geographical domain.

Demo 2: “How to use Femtocells, EPC, NFV, USRPs on the Fed4FIRE testbeds” This demo will show how experiments can be set up easily and remote through Fed4FIRE tools and testbeds.

Demo 3: “Lash 5G” LASH-5G aims at experimenting an end-to-end service and resource orchestration system operating across cloud and network domains able to dynamically select the proper set of VF instances to address latency, adaptability and availability requirements of 5G applications.





## 5G-RANGE

### 5G-RANGE – PHY Layer for the 5G Remote Area Applications

Nowadays, the main research efforts on 5G networks aim for improving the data rate, reduce latency and increase the number of connections. Besides these efforts, one important scenario is not being intensively researched, which is the coverage in remote and rural areas. The main goal of the 5G-RANGE project is to conceive and implement a 5G operation mode that can provide reliable Internet access in remote areas, with significant social and economic impacts. 5G-RANGE will provide the telecommunications infrastructure to allow those living in low populated areas to have reliable Internet access. This solution will also support the agribusiness automation, allowing for using IoT for improving farms productions in the so-called smart farms. Other applications, such as road coverage and high-speed train connections, will benefit from the wide coverage provided by 5G-RANGE. The 5G-RANGE PHY must overcome several challenges. Cognitive radio techniques shall be employed to reduce operational costs. Hence, the waveform must have low out-of-band emissions and spectrum flexibility to support dynamic frequency allocation. The waveform also must achieve high spectrum efficiency under a double-dispersive channel with long delay profile. Finally, state-of-the-art channel codes and MIMO schemes must be used to provide robustness for large cell coverage. The main aim of this demonstration is to show the preliminary results achieved by the 5G-RANGE Project in terms of the PHY for Remote Area Applications. The transceiver is entirely implemented in hardware and is able to operate in real-time at high data rates. We will demonstrate that the conceived PHY layer is able to achieve very low out-of-band emissions, which allows spectrum agility by just turning off subcarriers in undesired spectrum bands. The system robustness is assured by a flexible Polar Code, which can be configured to operate at different code rates and by a MIMO diversity scheme to enhance robustness.



## 5G ESSENCE

### 5G ESSENCE – 5G Small Cells for Multitenancy and Edge Services

The 5G ESSENCE project “addresses” the paradigms of Edge Cloud computing and Small Cell-as-a-Service (SCaaS) by fuelling the drivers and removing the barriers in the Small Cell (SC) market, forecasted to grow at an impressive pace up to 2020 and beyond, and to play a “key role” in the global 5G ecosystem. The 5G ESSENCE framework provides a highly flexible and scalable platform, able to support new business models and revenue streams by creating a “neutral host” market and reducing operational costs by providing new opportunities for ownership, deployment, operation and amortisation. Two demonstrations will showcase the system design, concepts and visions developed by the 5G PPP H2020 project “5G ESSENCE”.

**Enhanced Video Services at the Edge DC:** The demo will show the i-EVS (Enhanced Video Services) application leveraging the Multi-Access Edge Computing (MEC) platform hosted in the 5G ESSENCE Edge DC, which provides a virtualized layer and allows the high processing of content at the network edge. The i-EVS offers video transcoding capability as well as Context-Aware and Location-Aware mechanisms, enabling Service Providers to launch new value-added services.

**Data traffic characterization & multitenancy at the network edge:** 5G-ESSENCE offers content providers cloud computing capabilities at the edge of the mobile network. It is characterized by low latency and

high bandwidth, and provides real-time radio network information to applications that can run in this environment. During the exhibition, 5G ESSENCE will focus on two main aspects of the project: the multitenancy in the 5G Cloud Enabled Small Cells (CESCs) and the progresses done in providing the two tier cloud computing services at the edge of the network.

#### Booth #13



### SEMIoTICS

#### SEMIoTICS Platform

The SEMIoTICS platform will demonstrate an end-to-end IIoT SDN/NFV infrastructure:

A mini cluster of ARM Single-Board Computers (SBCs) will act as the local cloud. The ARM SBCs will act as a set of Compute Nodes, or Hypervisors, that will host all the relevant VNFs (e.g., related to smart actuation, monitoring, and data analytics)

An Odroid C2 minicomputer will act as the Field layer Virtualized IoT gateway that can host VFNs to reduce latency. An 802.15.4 radio module will be employed to interconnect Field devices (smart sensors) with the gateway

Field layer smart sensors will transmit temperature, humidity, and light intensity values wirelessly over 802.15.4, while their inputs will directly control actuators (e.g., smart light bulbs).

OpenHab IoT platform will be employed for sensor value visualization (charts) which will be displayed on a Tablet.

SDN switching will be employed for the Network Layer

During our demo, individual VNFs (related to monitoring, actuation, etc.) will be pushed to either the Cloud or the Field layer in real-time by a VNF Manager platform, demonstrating the effect on different KPIs (e.g., latency). SDN control will be employed to prioritize sensor traffic in the presence of competing background traffic.

#### Booth #14



### SHIELD

#### Next-generation Security-as-a-Service

The objective of the demo is to show the SHIELD solution for two-tier network protection based on the Security-as-a-Service (SecaaS) paradigm. The SHIELD security service model includes i) virtual network security functions (vNSFs) deployed into the network and ii) threat/incident detection based on Big Data analytics, exploiting data collected by the vNSFs. vNSFs, as virtual security appliances, achieve a first level of protection by detecting and blocking threats based on known rules. At the same time the SHIELD Data Analysis and Remediation Engine (DARE) collects information from the vNSFs (e.g. flow data and HTTP/DNS logs) and attempts to infer anomalies and incidents which were not detected by the vNSFs themselves.



## NGPaaS

### Next Generation Platform as a Service

Today's PaaS offerings are tailored mainly to the needs of web and mobile applications developers, and involve a fairly rigid stack of components and features. The vision of the H2020 5GPPP Phase 2 Next Generation Platform-as-a-Service (NGPaaS) project is to enable "build-to-order" customized PaaS, tailored to the needs of a wide range of use cases with telco-grade 5G characteristics. NGPaaS will demonstrate the platform based 5G design and the 'build-to-order' principle through three PoCs: 1) "one click deployment" of an end-to-end mobile network over a distributed cloud infra-structure FRONT-END/EDGE/CENTRAL/PUBLIC clouds. The Cloud RAN is implemented in a pure software running as containers. The fronthaul network is intent based. Part of the 5G CORE network will be deployed in a public cloud e.g. Amazon, 2) A pilot Dev-for-Operations based on 3 vendors, 1 NGPaaS Operator and 2 Verticals, demonstrating the "build to Order" of Continuous Integration/Continuous Delivery (CI/CD) environment for Vendors and for Operators. The Demo will show how life cycle of a VNF can be automatized from code to live production environment, 3) A Telco PaaS using a NGPaaS-compliant CORD as the platform, with the Virtualized Network Function as a Service (VNFaaS) service model, to deploy VNFs like virtual routers and firewalls for fixed network and also value-added services like on-demand monitoring of the deployed VNFs.

In addition to demonstrations, project-prepared posters, and brochures, a white paper prepared by BT will be released. Entitled 'Network Operator's Perspective on NGPaaS', the white paper addresses key innovative characteristics of the NGPaaS concept, and explores the potential benefits and market opportunities that could arise for network operators.



## TRIANGLE

### TRIANGLE E2E Testing Services

The TRIANGLE project will showcase a full End-to-End testing demonstration. The Triangle testbed is a full end-to-end system that includes COTS mobile devices, NB-IoT devices, reference mobile applications, full RAN emulation and EPC for 4.9G. The demo will allow the user to access an instance of the Triangle testbed and perform testing on reference applications, by recording customized user flows for mobile applications, the demo will also make use of the remote testbed features to demonstrate the ease of access of the Triangle testing service.

The demonstration will perform automated testing on a set of use cases, including the trending VR by mean of a custom-developed robotic arm for 3D real movements. The demo will show how easy it is to set up App or device testing with the testbed developed by the TRIANGLE project. One important lesson learned from past FIRE projects is the difficulty of accessing and using the different testbeds offered by the community. In the TRIANGLE project, valuing the offer of a good testing experience to the testbed's potential customers, we have developed different entry points to the testbed fitting the different amount of knowledge expected from different customer profiles.



## SELFNET

### **SELFNET – Framework for Self-Organized Network Management in Virtualized and Software Defined 5G Networks**

As of today, maintenance and servicing of permanent growing mobile networks require manual intervention of qualified network engineers to ensure a constant high level of service quality, which is very time and cost consuming. Operators need to locate and mitigate different types of problems in the network, such as hardware faults, link failures, performance optimization and security attacks, to only name a few. The European Commission (EC) and others highlighted already in 2014 that mobile operators spending three times operational expenditures (OPEX) than capital expenditures (CAPEX). With the emerging Fifth Generation (5G) and therefore gaining heterogeneous and complex networks as well as challenging requirements of new use cases, will increase this number further. The network function virtualization (NFV) and software-defined network (SDN) principles of the future core networks allow more flexibility but also enable the option to automate many of that maintenance and management tasks with the help of artificial intelligence (AI).

The EU H2020 SELFNET project is addressing these challenges and developing a self-organized 5G network management framework through virtualized and software-defined networks to support these new technologies. Since this reduce manual interventions by network engineers it is significantly reducing operational costs while at the same time improving the user experience. You can see the following demos at our booth:

Cybersecurity Techniques - The Self-Protection Use-Case

Trust Node - Hardware accelerated Self-Optimization Use-Case

Autonomous VNF fault mitigation - The Self-Healing Use-Case

SELFNET GUI - Your Network Status at a Glance

SDN / NFV - Application Management

AI in 5G – Zero Touch Network in the Self-Healing Context



## 5GinFIRE

### **5GinFire testbed by bcom**

Because 5G is not only a New Radio interface, how can a project pave the way from current 4G architecture to a 5G-oriented experimental playground? This is the main target of 5GinFire H2020 project and the partners have addressed this challenge during the first of half of the project. Based on cloud infrastructures provided by various partners, 5GinFire built a platform which is compliant with ETSI NFV reference model and relies on carrier grade solution on top of OpenStack (<https://www.openstack.org>) as a Virtual Infrastructure Manager and on release TWO of Open Source MANO (<https://osm.etsi.org>) as a VNFs orchestrator.

The main objective is to showcase the capacity of the 5GinFIRE testbed with the ability to deploy a complex Network Service (NS) with Open Source MANO. For this demonstration, the NS is the Unifier Gateway, a VNF developed by bcom, which provides a multi-access IP connectivity with various radio access technologies (LTE, WiFi, LoRa). It includes 4G core network functions like MME and HSS but already takes benefit from an SDN framework to introduce pre-5G concepts like CUPS (Control and User Plane Separation). It interconnects with legacy WiFi access points and 4G LTE eNodeB. The key point of such an integration in Open Source MANO is the time-to-deploy, with the target to deploy a full core network within a few minutes.





## 5G-MoNArch

The focus of the 5G-MoNArch project is on developing a flexible, adaptive, and programmable mobile network architecture for 5G, and to bring these concepts to practical implementation. The basic architecture concepts such as network slicing and user-/control-plane separation are completed and enhanced with a number of vertical use case-driven innovations, e.g., a cloud-enabled network protocol stack, inter-slice control and management, resource-elastic network functions and resilient and secure network functions. These innovations support the requirements of two use cases, which are worked out, namely, network slicing for industrial resilient and secure applications, and network slicing for resource elastic media & entertainment use cases. 5G-MoNArch implements these two use cases into dedicated real-world testbeds: The Hamburg Smart Sea Port representing industrial applications, and the Turin Touristic City representing media & entertainment use cases.

The demonstrator, posters and video material presented at the exhibition provide an insight to the ongoing research work of 5G-MoNArch, and intermediate results from the project's requirements and development phases. This material shall leverage discussions with visitors from industry and academia, showcase the advances of the underlying technical concepts, and enable to gather further feedback on the project's work approach.



## 5GTANGO

### **5Gtango – 5G Development "and Validation Platform for Global Industry-Specific Network Services and APPs**

5GTANGO puts forth the flexible programmability of 5G networks with i) a NFV-enabled Service Development Kit (SDK), ii) a validation and verification platform with advanced validation and verification mechanisms for VNFs/Network Services qualification (including 3rd party contributions), and iii) a modular Service Platform with an innovative orchestrator in order to bridge the gap between business needs and network operational management systems. The combination of the proposed SDK toolkit, validation and verification platform and the service platform realises an extended multi-modal NFV DevOps model between service developers, telecom operators and vertical industries, increasing operational efficiency, facilitating the implementation and validation of new services and accelerating the adoption of NFV technologies.

The demo will cover the three phases for the development, validation & verification and deployment of an Industry-specific virtualized application. An example of VNF will be used in order to demonstrate the presented 5GTANGO release 1. First, using the SDK it will be packaged as VNF. Later, V&V Platform will be used to verify and validate the packaged VNF. Finally, Service Platform will deploy a network service using the validated and verified VN



# MATILDA

## MATILDA

### MATILDA – Orchestrating 5G Ready Emergency Services

The vision of MATILDA is to design and implement a holistic 5G end-to-end services operational framework tackling the lifecycle of design, development and orchestration of 5G-ready applications and 5G network services over programmable infrastructure, following a unified programmability model and a set of control abstractions. It aims to devise and realize a radical shift in the development of software for 5G-ready applications as well as virtual and physical network functions and network services, through the adoption of a unified programmability model, the definition of proper abstractions and the creation of an open development environment that may be used by application as well as network functions developers. Intelligent and unified orchestration mechanisms will be applied for the automated placement of the 5G-ready applications and the creation and maintenance of the required network slices.

The objective of the demonstration is to showcase the first release of the MATILDA orchestrator capabilities based on 5G Ready Emergency Services Use Case demonstration.



## INTERNET INSTITUTE

INTERNET INSTITUTE Ltd. (ININ) is an innovation intensive SME, specialized in QoS and QoE measurement solutions, quality assurance systems and services, and emergency response and intervention management tools for public safety needs. We have expertise in 5G performance and quality metrics development and validation, 5G benchmarking and end-to-end KPIs validation, and quality monitoring and SLA assurance for orchestrated 5G infrastructures and services. Also, we are experienced in design and deployment of reliable and resilient 5G infrastructures for public safety needs.

We will showcase two products at our booth at EuCNC 2018. ININ addresses telco, corporate and vertical industrial sectors with our qMON (quality MONitoring) portfolio for quality monitoring and SLA assurance, benchmarking and end-to-end validation of communication infrastructures and services. In addition, with iMON (Intervention MONitoring) portfolio, we specialise in design, development and integration of on-site and backhaul critical communications solutions and intervention monitoring tools and apps for the public safety sector. We cooperate tightly with PPDR (Public Protection and Disaster Relief) practitioners and we are involved in several R&D and piloting projects addressing the delivery of future proof communication systems, services and apps for 112 and emergency response needs.

ININ is active in R&I and industrial projects domain and is part of the 5G PPP Phase 2 program (project MATILDA, [www.mati-lda-5g.eu](http://www.mati-lda-5g.eu)). We work on monitoring and QoS and QoE evidence collection capabilities in the 5G-orchestrator solution. Also, we are involved in planning and implementation of 5G vertical use cases for the emergency response domain, including piloting in realistic environments in joint cooperation with PPDR practitioners. Our particular interests for upcoming 5G research are: quality assurance of mobile, fixed and cloud systems, including 5G performance and quality metrics development and validation, 5G testing, benchmarking and 5G end-to-end KPIs validation; quality monitoring and SLA assurance for 5G infrastructures and services; and R&I and piloting of resilient real-time 5G critical infrastructures, and specialised 5G deployments for public safety, automotive and intelligent transport, and smart grid verticals.



## 5G PPP SMEs

### 5G PPP SMEs – SMEs Expertise and Innovation in the 5G Domain

European Small and Medium-sized Enterprises (SMEs) provide great added value in developing innovative concepts and solutions that are key to boost the establishment of 5G technologies and their adoption across several vertical industries. SMEs have the agility and flexibility required in a fast evolving technical and market landscape. They increasingly collaborate with large industrial companies and research organisations to develop disruptive technologies for the global market, playing an important role in piloting and deploying 5G technologies. Visit the 5G PPP booth to meet selected SMEs presenting their latest 5G achievements.

**Internet Institute**, based on the advanced BI tools the demonstration, will show in a graphical way the status of the mobile network and state of running services.

**Martel Innovate** will present a demo showcasing the Orchestra Cities platform, developed in collaboration with two other SMEs (Ubiwhere and Therapaenis).

**Montimage** will present a demonstration of monitoring of performance and detection of security breaches in SDN/NFV environment.

**Nextworks** will present a preliminary demonstration of a service driven Network Slicing Management component for 5G Mobile Transport and Computing Platforms, with instantiation of ultra-high definition media distribution functions over virtual CDNs.

**Trust-IT Services** will show a video of 5G verticals within the 5G PPP, market potential and standardization, illustrating how SMEs and other EU companies are contributing to the transition to 5G with high potential impacts for the EU Digital Single Market.

**Ubiwhere** will present a demo showcasing the important role of an open access model, or neutral host, is in the upcoming 5G era.

**Visiona** will present the preliminary developments of two virtual functions for media processing and drone flight control (vMPA and vDFC) being developed as part of Use Case 2 Preventive Maintenance of Critical Infrastructures within NRG-5 project.

**WINGS-ICT Solutions** will be distributing flyers and promotional materials presenting their latest innovative solutions.

**Learn more** about these SMEs online!



## 5G PPP – The 5G Public Private Partnership

The 5G Public Private Partnership (5G PPP) has been initiated by the EU Commission and industry manufacturers, telecommunications operators, service providers, SMEs and researchers. The 5G PPP will deliver solutions, architectures, technologies and standards for the ubiquitous next generation communication infrastructures of the coming decade.

The objective of the exhibition booth is to increase the visibility of 5G PPP among everyone working on 5G. It will provide overview information on the PPP overall as well as summary information of individual projects in current Phase 2. This will help visitors to find out what projects are working on and how to get in touch with them.



## SaT5G

### SaT5G – Satellite and Terrestrial Network for 5G: Demonstration of Satellite Integration Towards 5G

SaT5G is a European Commission H2020 5G PPP Phase 2 funded project, whose vision is to develop a cost effective “plug-and-play” satcom solution for 5G to enable telcos and network vendors to accelerate 5G deployment across all geographies and multiple use cases. Among other objectives, the SaT5G project aims to demonstrate selected key 5G features and use cases across three main EU testbeds, currently under development, two of which involving geostationary (GEO) and non-geostationary (MEO) in-orbit satellites.

Building upon the currently ongoing work and intermediate results available within the SaT5G project, this demo aims to progress the State-of-the-Art and demonstrate over-the-air selected 5G features and use cases for satellite network integration using an existing in-orbit geostationary satellite system. In particular, the objectives of the demo are:

To demonstrate over-the-air the 3GPP core network integration of satellite networks using an SDN/NFV/MEC-enabled pre-5G construction testbed currently under development with an in-orbit geostationary satellite system;

To demonstrate key satellite backhauling features for 5G networks;

To showcase 5G use cases towards efficient edge delivery of multimedia content based on content caching and CDN integration enablers;

To exercise the intermediate testbed demo setup, incorporate feedback and lessons learnt and, thus pave the way forward for the upgrade of the testbed towards the next planned SaT5G over-the-air demonstrations, as well as identify the subsequent SaT5G standardization activities to be undertaken with respect to 3GPP and ETSI;

To showcase key benefits of satellite integration into the 5G network of networks, through an innovative live over-the-air demonstration and in front of a wide audience, mainly comprising of terrestrial stakeholders.



## SLICENET

### RAN Runtime Slicing System

The proposed demo has the three main objectives highlighting several important aspects of network slicing developed in the context of SliceNET project, including

Showing how the network slicing runtime system enables the dynamic creation of slices with QoS support, while providing functional and resource isolation among different slices (e.g. verticals).

Characterizing the efficiency and flexibility of the proposed RAN runtime to partition and allocate radio resources among different slices based on the service QoS and the corresponding SLAs.

Demonstrating a novel plug & play RAN execution environment provided to chain network control applications so as to customize and control RAN slices as per service requirements.

The considered demos has applications in multiple use-case considered in the SliceNet project such as e-Health belonging to the uRLLC slice type, where QoS is of paramount importance to support time-critical video transmission between the on-the-spot paramedic and doctors in the hospital and in the vicinity of the incident.





## 5G PPP IoRL

### **Early results supporting improved indoor 5G service delivery through the integration of visible light communication (VLC) with mmWave remote radio heads**

The 5G PPP Internet of Radio Light (IoRL) project strives to improve indoor 5G connectivity and service delivery by integrating visible light communication and mmWave Remote Radio Heads. The conceived framework offers significant improvement concerning several 5G KPIs in indoor environments, whilst minimizing interference, power consumption and EM exposure and providing location accuracy of less than 10 cm.

The objective of the exhibition is to showcase some early results from the IoRL project, demonstrating the potential of the technical solution. The preliminary results of the integration of 5G New Radio access point with 5G UE will be presented. The exhibition should serve also as a meeting point where IoRL partners can discuss with the other 5G PPP projects how IoRL technology can be combined with their solutions to reach the 5G PPP performance objectives.



## FUTEBOL

### **FUTEBOL – Federated Union of Telecommunications Research Facilities for an EU-Brazil Open Laboratory**

The FUTEBOL project is an H2020 project with the target of building a multi-institutional federated laboratory across Europe and Brazil. The experimental facilities of the FUTEBOL project are open-access to the researchers and students worldwide. The demonstrations we are showing in this booth are the latest experiments running on the FUTEBOL federated testbeds. Through the demonstrations we target to disseminate the testbeds of the FUTEBOL project and the innovative experiments running on these testbeds, with the coverage of these following research areas:

Wireless and optical network convergence for Cloud-RAN

Licensed shared access for extending LTE capacity

by multiple FUTEBOL partners (Trinity College Dublin, imec, VTT, IT).



## River Publishers

Incorporated in Denmark, and with offices in The Netherlands, Japan, USA and India, River Publishers is active in many areas of Science and Technology, and we publish peer reviewed research books and journals in these fields.

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## EuCNC 2019 VALENCIA

EuCNC 2019 is the 28th edition of a successful series of a conference in telecommunications, hosted in Valencia, Spain. EuCNC 2019 will be co-located with the Global 5G Event, which brings together the world 5G industrial associations: 5G-IA, IMT-2020, 5G-Forum, 5G-MF, 5G-Brasil and 5G-Americas.





## JOŽEF STEFAN INSTITUTE

The Department of Communication Systems at Jožef Stefan Institute, a local co-host of the EuCNC 2018, has a long tradition of participating to international collaborative research in the domains of wireless and mobile communications, parallel computing, and sensor networks. Currently it is contributing to five H2020 projects (eWINE, Fed4FIRE+, DEFENDER, NRG-5 and SAAM), covering different aspects from basic and applied research to prototyping, piloting and testbed experimentation. Some of the recent achievements demonstrated at the booth include.

Wireless research testbed supported Continuous Integration for LoRa firmware development (DEMO 1): Demonstration of the Continuous Integration (CI) framework implemented in the LOG-a-TEC testbed on an example of LoRa firmware development. Built from a set of open source tools and a social coding platform, the framework is showcasing how multiple developers, simultaneously working on the same code-base, can use automated testing on a real testbed to discover the integration problems and fix them early in the development process.

Automatic detection of wireless spectrum events from streaming spectrum sensing data (DEMO 2): Demonstration of a scalable, technology agnostic system that is able to automatically detect wireless spectrum events from streaming spectrum sensing data. Without any prior training, it enables the consumption of the events as they are produced, as a statistical report or on a per-query basis. The system delivers actionable information to humans and machines and enables better spectrum and network resource management as well as QoS provisioning.

UWB-based indoor localization (DEMO 3): Demonstration of a ultra-wideband (UWB) indoor localization application based on measured ranges (time of flight) between tracked nodes and fixed reference anchor nodes. The application uses non-line of sight (NLoS) classification model and ranging error estimation model for localization error mitigation, both based on convolutional neural networks (CNNs).

Demonstration of continuous power quality assessment in a data center (DEMO 4): Demonstration of the continuous power quality assessment system deployed at a data center and aimed at designing automation strategies for downtime reduction, efficiency improvement, and coordination with the power grid. Such systems are increasingly important in data centres due to their large power consumption, mission critical operation and a significant share of non-linear loads with impact on the degradation of power quality and energy efficiency.

Phasor measurement units as a showcase for 5G in smart grids (DEMO 5): Demonstration of electricity distribution grid real time monitoring using Phasor Measurement Units (PMU). Huge amount of phasor measurements (50 samples of magnitude and phase per second) that need to be transferred securely and in real time are the key input to the distribution system state estimation (DSSE) or other advanced smart grid monitoring/management applications, representing one of important application areas for 5G technologies.

Personal ECG monitoring device (DEMO 6): Demonstration based on a medical-grade wireless ECG body sensor of small dimensions, flexible design and seven-day power autonomy, designed at JSI and commercialized by SAVING under the trademark Savvy. The ECG body sensor supports real-time monitoring of the heart rhythm via personal smart device, representing a healthcare 5G vertical application example requiring high throughput per device and in certain environments, such as hospitals, rehabilitation centers and elderly homes, very high density of such devices. The demonstration will also show the possible use of the sensor for collecting contextual information about the user.



University of Ljubljana  
Faculty of Electrical Engineering

**LTFE** Laboratory for  
Telecommunications

**LMMFE** Laboratory for  
Multimedia

## UNIVERSITY OF LJUBLJANA

The Laboratory for Telecommunications (LTFE) and the Laboratory for Multimedia (LMMFE) are based at the Faculty of Electrical Engineering, University of Ljubljana. With more than 40 associates, top experts from various professional fields and industrial partners, they are one of the leading pioneering research groups. The laboratories strive to establish a creative environment for the students, partners and employees by successfully harmonizing ICT research, pedagogical and project work. By pursuing knowledge of the highest degree, hands-on experience and business excellence they pave the way to new ideas, solutions and results. With more than 60 years of experience and tradition they can take up any challenge in contemporary and future fields of telecommunications and ICT.

Propulsive research teams are developing and implementing research projects in various fields, and apply the insights to different sectors of the economy. LTFE and LMMFE are highly committed to the research, development, pilot integration and trials of technologies and system solutions, examples of which will be demonstrated at EuCNC 2018, as follows.

**NEXt Generation Emergency Services (DEMO 1):** In NEXES were developed the research and development of next generation emergency services that integrate IP-based communication technologies and interoperability. NEXES delivers innovation to 112 services across Europe, enabling the use of total conversation capabilities in emergencies, the exploitation of improved location information and the advantage of Internet-enabled connectivity.

**Electrical switch with Ethereum blockchain support (DEMO 2):** SWEATHER is based on end-to-end prototype system comprised of IoT devices decentralized applications (DAPPs) and user interfaces. It is a practical application of blockchain technologies in IoT devices. It enables control of electric switch via Ethereum blockchain transactions. The user can book electric charging slot and pay for consumed time/energy via Ethereum network.

**A Sports Application in the World of Upgraded Reality (DEMO 3):** Within the project we developed a solution that will allow the user to monitor sports transfers with additional information in the world of upgraded reality. The application runs on the Microsoft HoloLens header display and displays real-time statistics for various sports statistics and provides simple betting related to the various events in the game. The main focus of development is on providing superior user experience and ease of use.

**Rehabilitation of Precise Movements of the Upper Limbs in the Virtual Reality Environment (DEMO 4):** We developed a system for the rehabilitation of precise movements of the upper limbs in the virtual reality environment. The game was developed in close cooperation with the University Rehabilitation Institute Soča, where the solution is tested and used. The game has several difficulty levels and allows you to track the movements of the user in the rehabilitation process. The solution works by using Oculus Rift's virtual glasses and the Leap Motion sensor, which serves to track the movements of the upper limbs of the user.

**Digitally enabled learning and knowledge sharing for enterprises (DEMO 5):** E-CHO is a system that helps companies, banks, educational organizations to introduce advanced technology solutions for e-learning and multimedia learning, thus enabling: lower training expenses, use learning to increase business performance, streamline the exchange of key knowledge among employees, effectively established certification of staff or partners, systematically transfer knowledge into multimedia content and train a large number of employees in a very short time.



Opto-electronic oscillator (DEMO 6): An opto-electronic oscillator presents a practical application for the next generation of 5G mobile and wireless networks based on millimeter-wave technology. The application of a single-loop, opto-electronic oscillator is designed for 39 GHz and will be implemented in the central-station of an upcoming 5G mobile and wireless network. The aim of this configuration is to decrease the complexity of the base-stations for a next-generation system and provide an economic advantage for upcoming 5G networks. The system is designed to avoid the power penalty due to the chromatic dispersion, is temperature stabilized to have a long-term stability and has a low side-modes effect to ensure a low phase noise.







## GUIDED TOURS AND TOURIST INFORMATION

**IN SLOVENIA, SHORT DISTANCES GO HAND IN HAND WITH EXTRAORDINARY DIVERSITY AND THERE IS SOMETHING FOR EVERY TRAVELLER'S TASTE.**



Postojna Caves, photo Slovenia.info, Iztok Medja

Head to the Postojna Caves for a day of an unforgettable adventure, enjoy an active day in the Julian Alps, visit the fairytale Lake Bled, discover the hills of Goriška Brda, pamper yourself with a visit to one of the many luxurious thermal spas, or enjoy a museum train ride along the emerald Soča valley. With a bit of planning, you can enjoy the snowy slopes of Alps in the morning followed by a dip into the Mediterranean Sea in the afternoon.

Guided activities are organized for EuCNC 2018 delegates during the conference:

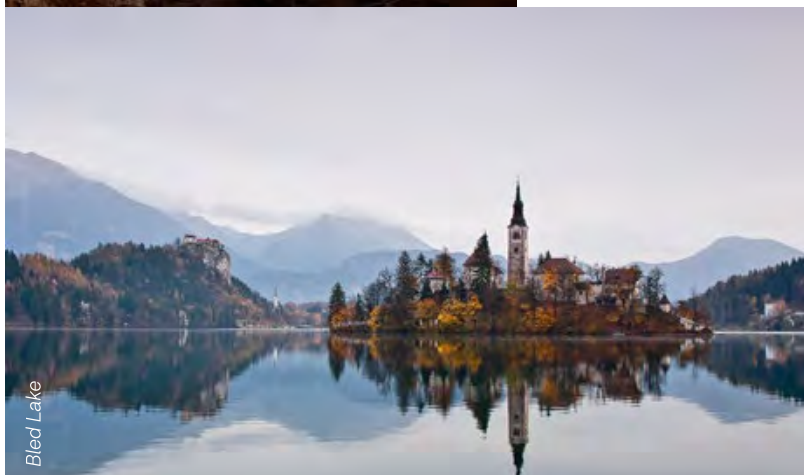
Guided tour of the **Historical city centre and Ljubljana Castle**, a free guided tour provided to EuCNC 2018 delegates by the Ljubljana Tourism

**Bled Lake Experience** in the fairytale Alpine region

**Postojna Cave & Predjama Castle** for an adventure in the world-renowned underground Karst caves

All tours are organized on Thursday June 21 2018 at 14:30.

For more information, please visit the conference website at <https://www.eucnc.eu/touristic-tours/>



Bled Lake

Make the most of your stay in Slovenia by taking time to explore its beauties! A broad choice of touristic tours is available for every taste. Please visit Ljubljana Tourism website at <https://www.eucnc.eu/touristic-tours/> for more ideas!



Ljubljana, photo Slovenia.info, Iztok Medja





Predjama Castle, photo Slovenia.info, Valter Leban



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Our strong cooperation with the ICT industry results in our knowledge being used by millions of users around the world. We also have long-standing project and development partnerships with the European Commission and other international bodies.

Meet us at EUCNC 2018 to see exclusive 5G-ready research prototypes that combine the power of optical communications and microwave photonics, blockchain-based smart power solutions and virtual reality applications: NEXES, a pan-European emergency services connectivity solution, FiWi5G, a fiber-wireless integrated solution for 5G delivery, SWETHER, a smart electrical outlet running on Ethereum, and virtual and augmented reality user interface prototypes.

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- SECURE DATA TRANSFER WITH MINIMAL POWER CONSUMPTION
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- USER AWARE DESIGN WITH SOCIAL INTELLIGENCE AND MACHINE LEARNING
- ICT TRAININGS FOR EXECUTIVES AND OPERATIVES

Visit our stand and discover joint opportunities to drive forward 5G and 6G innovation, either in industry or in your next research project. The following experts will be on-site during the event, ready to connect with you. Reach out to secure your time slot.

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Laboratory for telecommunications (LTFE) is the premier research laboratory for ICT, communications and emerging technologies at the University of Ljubljana, the largest research and educational institution in South-Central Europe.

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IskrateL is the leading European ICT provider for the digital transformation of the telecommunications, transport, public safety and energy industries. With its own R&D and manufacturing centres, over 900 employees and global footprint in more than 50 countries, IskrateL combines experience and expertise with creativity and innovation. We strive to create value, ensure safety, increase efficiency and improve quality of life. As we continue to expand our global reach, we continue to focus on local specifics and providing each customer with a personalised service. We deliver to ensure the success of our customers and business partners. Our focus is on creating cutting-edge, integrated solutions for telecommunications operators, service providers and the digitalisation of the transport, public safety and energy industries. We empower telcos to deliver end-to-end services that residential and business users expect. We modernise networks and maximise profits in a smart and cost-effective way.

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## SUPPORTER



EuCNC 2018 has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 761434 (EuConNeCts3 Project).

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At the **Dept. of Communication Systems**, we have been for almost 3 decades...

... working at the junction of **basic** and **applied** research, development and innovation, **prototyping** and **piloting**, simulation and **experimentation**, witnessing and contributing to the development of new generations of mobile communications, wireless technologies and networking solutions.

... challenged by the need for provision of **efficient and reliable communications** for people, computers, networks, machines and things; by the necessity to distinguish signals from noise, information from mere data; by the communication requirements on scales from satellites and UAVs down to between- and within processors.

... driven by the need to **transfer knowledge** to real life problems, to apply it in different domains from health and elderly care to structural analysis and chemistry, from telecommunications to smart grids and transport, with industrial partners or through project collaborations.

### FACTS & NUMBERS:

- 25 years of tradition in international collaborative projects
- 30+ researchers
- > 100 journal papers since 2013
- on average running 3 basic research projects yearly totalling approx. 10 FTE
- currently contributing to 5 H2020 projects (eWINE, SAAM, NRG-5, DEFENDER, Fed4FIRE+)

### OUR EXPERTISE:

- **wireless and mobile communications, sensor networks and parallel computing**
- covering various aspects from **hardware** and **software** development to the design of **protocols** and **applications**
- operating the LOG-a-TEC testbed for experimentation with low cost flexible wireless devices
- technology transfer to start-ups and industrial partners; recent transfers include a personal ECG device, a phasor measurement unit and a power quality meter, all demonstrated at our booth

We are open to discuss research challenges and new collaboration opportunities. Meet us at the booth in the exhibition area where we are proudly demonstrating some of the recent achievements.

### DEMOS AT OUR BOOTH:

- **indoor UWB-based localization** technology **running live** and **using Convolutional Neural Networks** for increased accuracy
- **real-time automatic detection of wireless spectrum events** for machines and humans
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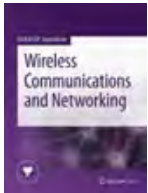
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# Special issue

## Systems and Networks for 5G Implementation

*EURASIP Journal on Wireless Communications and Networking* will publish a Special Issue with papers submitted to the Thematic Series on "Systems and Networks for 5G Implementation".

This Special Issue originates from the conference EuCNC 2018 (European Conference on Networks and Communications), which is being held in June 2018, in Ljubljana, Slovenia. Through this Special Issue, the state-of-the-art will be presented and the new challenges will be highlighted, regarding the latest advances on system radio interfaces and network architectures, including cloud and virtualisation solutions, management technologies, and vertical application areas, among others, suitable for various 5G industries. The motivation for this Special Issue is the presentation of the latest and finest results on 5G research and prototyping activities. The scope of this Special Issue is to focus on systems and networks for 5G implementation.

The authors of the best papers will be invited to submit an extended version of their paper (it needs to be sufficiently different from the conference counterpart, at least 1/3 of additional material, and the common part should not simply be a copy and paste of the EUCNC paper).

### Submission instructions:

Before submitting your manuscript, please ensure you have carefully read the Instructions for Authors in *EURASIP Journal on Wireless Communications and Networking*. The complete manuscript should be submitted through the EURASIP Journal on Wireless Communications and Networking [submission system](#). To ensure that you submit to the correct Thematic Series please select the appropriate section in the drop-down menu upon submission. In addition, indicate within your cover letter that you wish your manuscript to be considered as part of the Thematic Series on "Systems and Networks for 5G Implementation". All submissions will undergo peer review and accepted articles will be published in the journal as a collection in a single issue.

**Deadline for submissions:** 16<sup>th</sup> October 2018

### Guest editors:

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# 5G AND BEYOND

## FINAL PROGRAMME

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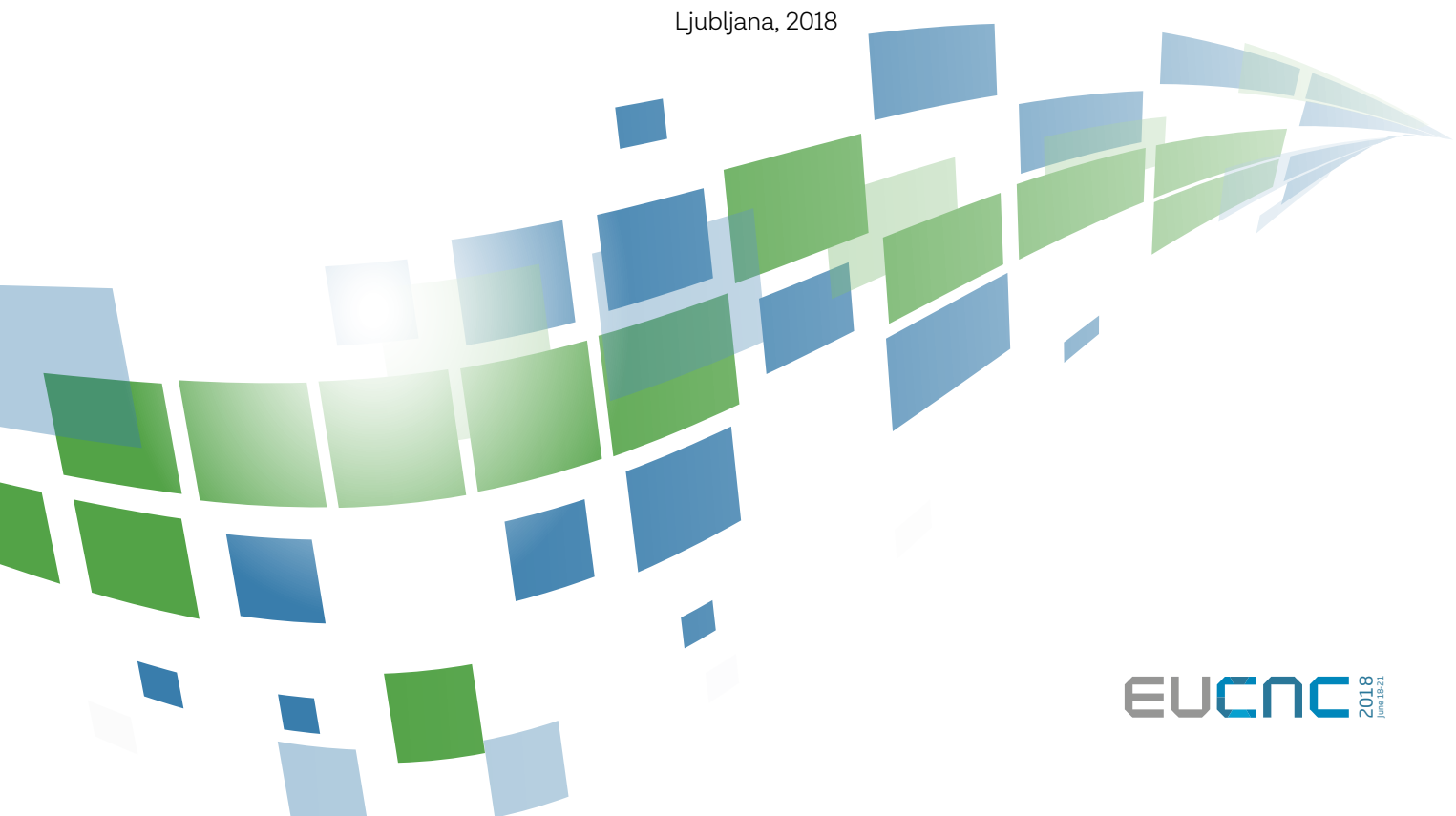
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