# Workshop

# Big Data for Reliable 5G Networking

## organized by COST Action IC1304 (ACROSS)
## hosted by EUCNC 2016, Athens, Greece, 27 June 2016

## Workshop Co-Chairs

Hans van den Berg (TNO / University of Twente, Netherlands)
Rob van der Mei (CWI / VU University Amsterdam, Netherlands)

## Motivation and Background

5G aims at bringing new, distinctive network and service capabilities fulfilling the needs of the future Internet of Things. Besides new radio access capabilities, network softwarization through emerging technologies such as Software Defined Networking (SDN) and Network Functions Virtualization (NFV) as well as Mobile Edge Computing (MEC) are introduced to provide the means and flexibility needed to reach the required performance and scalability targets in an efficient way. However, to actually achieve the full potential of future 5G networks, huge challenges regarding network and system management are faced. Data analytics and Big Data techniques exploiting data coming from countless network devices in forms of device logs, usage histories, media contents delivered over networks and so on, provide a promising direction to prevail these problems. The workshop addresses fundamental scientific challenges regarding the use of Big Data techniques for 5G network management. Specific topics of interest include Big Data for resource and service optimization, Big Data for QoS/QoE driven self-management, monitoring behavioural data while guaranteeing the users' privacy, etc.

## Workshop Programme

14.00 – 14.30    **Rob van der Mei,** CWI / VU University Amsterdam, Netherlands
*Opening and introduction to COST ACROSS*

14.30 – 15.00    **Kostas Tsagkaris**, WINGS ICT Solutions, Greece
*Big Data and Machine Learning for optimized telecom operations*

15.00 – 15.30    **Jeroen Famaey,** University of Antwerp, Belgium
*SDN-based load balancing in heterogeneous local area networks*

15.30 – 16.00    *Coffee break*

16.00 – 16.30    **Fidel Liberal**, Univ. of the Basque Country, Spain
*Big Data implications: C-RAN vs. MEC*

16.30 – 17.00    **Periklis Chatzimisios**, Alexander Technological Educational Institute of Thessaloniki, Greece
*Big Data-Driven Optimization for Mobile Networks toward 5G*

17.00 – 17.30    **Martín Varela,** VTT, Finland
*QoE in 5G Networks, from Large-scale Monitoring to QoE-driven Network Management*

17.30 – 17.45    **Hans van den Berg,** TNO / University of Twente, Netherlands
*Wrap-up and closing*

# Short bios of speakers and abstracts of presentations

**Jeroen Famaey** is an assistant professor associated with iMinds and the University of Antwerp, Belgium. He received his M.Sc. degree in Computer Science from Ghent University, Belgium in 2007 and a Ph.D. in Computer Science Engineering from the same university in 2012. His research interests include protocol and algorithm design for wireless networks, specifically focusing on low-power sensor networks, coexistence in heterogeneous environments and deterministic QoS. He has coauthored over 60 papers published in international peer-reviewed journals and conference proceedings, as well as 8 patent applications. Moreover, he has been active in over 15 national and European research projects over the last 10 years.

**Abstract "SDN-based load balancing in heterogeneous local area networks"**
Today's local area networks (LANs) consist of a plethora of heterogeneous consumer devices, equipped with the ability to connect to the Internet using a variety of different network technologies (e.g., Ethernet, Power-Line, 2.4 and 5GHz Wi-Fi). While some of these devices are capable of only using a single technology, others have interfaces for several technologies at their disposal. Nevertheless, devices generally opt to statically connect using a single technology, based on predefined priorities. This static behaviour does not allow the network to unlock its full potential, which becomes increasingly more important as the requirements of services grow, and new technologies are being introduced to the network (e.g., 60GHz Wi-Fi or low-power wireless for IoT). To address this issue, we present a scheduling and load balancing algorithm that dynamically selects a suitable interface and path through the network for each flow, based on service requirements, bandwidth availability and current (wireless) link quality. In order to achieve the optimal solution, the algorithm requires accurate and real-time data about the network and its flows, and needs to estimate and predict certain unmeasurable variables. Moreover, the network needs to be dynamically configurable through SDN-based interfaces.

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**Fidel Liberal** received his PhD from University of the Basque Country (UPV/EHU) in 2005 for his work in the area of holistic management of quality (both QoS and QoE) in telecommunications services. His research interests include quality management and multicriteria optimization for multimedia services in NGNs and 5G, particularly the evolution of service provision over C-RAN and MEC architectures together with SDN and NFV. He has co-authored more than 50 conference and journal papers. Currently he is involved in the SESAME 5G PPP project http://www.sesame-h2020-5g-ppp.eu/.

**Abstract "Big Data implications: C-RAN vs. MEC"**
Future 5G networks will support unprecedented volumes of mobile traffic and heterogeneous devices and types of service, which will impose challenging requirements to the dynamic management procedures. The evolution towards Cloud-RAN concepts introduces the possibility of unifying the control planes in order to better exploit inter-cell and even inter-technology capabilities. Likewise, the adoption of SDN principles anticipates the unified management of the convergent heterogeneous data planes from a domain-wise central controller. At the same time, the introduction of edge service instances collocated with the Cloud-RAN functions opens the door for an improved dynamic joint optimization of mobile networks and services. As a result, and taking into account the foreseen data rates in 5G networks, the implementation of all these cognitive management cycles would result in a huge volume of input information that may jeopardize the performance of the system. The integration of big data techniques are considered critical in the design of 5G networks concerning the filtering and analysis of massive input data in multi-user multi-context scenarios.

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**Periklis Chatzimisios** serves as an associate professor at the Computing Systems, Security and Networks (CSSN) Research Lab of the Department of Informatics at the Alexander TEI of Thessaloniki (ATEITHE), Greece. Recently he has been a visiting academic/researcher at the University of Toronto, Canada, and Massachusetts Institute of Technology. He is involved in several standardization activities serving as a member of the Standards Development Board for IEEE ComSoc (2010–present) and lately as an active member of the IEEE Research Groups on IoT Communications & Networking Infrastructure and Software Defined & Virtualized Wireless Access. He is the author/editor of 8 books and more than 100 peer-reviewed papers and book chapters on the topics of performance evaluation and standardization. activities of mobile/wireless communications, quality of service/quality of experience, and vehicular networking. His published research work has received more than 1500 citations by other researchers. He received his Ph.D. from Bournemouth University, United Kingdom, in 2005 and his B.Sc. from ATEITHE in 2000.

**Abstract "Big Data-Driven Optimization for Mobile Networks toward 5G"**
Big data offers a plethora of opportunities to mobile network operators for improving quality of service. This article explores various means of integrating big data analytics with network optimization toward the objective of improving the user quality of experience. We first propose a framework of Big Data-Driven (BDD) mobile network optimization. We then present the characteristics of big data that are collected not only from user equipment but also from mobile networks. Moreover, several techniques in data collection and analytics are discussed from the viewpoint of network optimization. Certain user cases on the application of the proposed framework for improving network performance are also given in order to demonstrate the feasibility of the framework. With the integration of the emerging fifth generation (5G) mobile networks with big data analytics, the quality of our daily mobile life is expected to be tremendously enhanced.

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**Martín Varela** received his PhD and MSc from the University of Rennes 1 (Rennes, France), in 2005 and 2002 respectively. He has been an ERCIM fellow, and spent time at SICS and VTT, where he is currently a Principal Scientist. He has recently been a guest Senior Researcher at the Cooperative Systems Group at the University of Vienna. He leads VTT's work on QoE, and was a Finnish management committee member for the recently ended COST Action IC1003 Qualinet. He is currently co-chair for the IEEE MMTC QoE Interest Group. His research interests lie in the QoE domain, in which he has been active since 2002, with a particular focus on real-time QoE models for generic services, and applications thereof. He is particularly interested on issues related to QoE-driven cross-layer control, resource management and business applications.

**Abstract "QoE in 5G Networks, from Large-scale Monitoring to QoE-driven Network Management"**
Throughout the years, a large amount of effort has gone into understanding QoE, assessing it, and creating models able to estimate it more or less accurately. At the boundary between QoE and networking, much work has been done in topics of mapping network performance (QoS) to some notion of QoE, usually perceived quality, and moreover, on trying to use those mappings for performing network-, application- and cross-layer optimizations, attempting to improve the users' experience and reduce the service and network providers' expense. The advent of 5G networks, and the shift from purely technical aspects of telecommunications towards enabling new ubiquitous services with good user experience, makes these topics all the more relevant. However, implementing QoE management mechanisms in the heterogenous, multi-stakeholder context of 5G networks is far from being a solved problem. In this talk we will cover some of the challenges to be addressed, as well as technical directions for implementing QoE awareness and QoE-aware management in 5G networks.