Defining and Realising SINR in Future Mobile Networks

Date: **Monday 16th to Tuesday 17th April 2018**
Venue: University of Surrey, Guildford, UK
(Less than one hour travel from London, the venue of EuCAP 2018 ending on Friday 13th April 2018)

This joint training school organised between IRACON and is drawing attention to the need to realise the complexities of interference between multiple wireless devices in future mobile networks. Issues include, but are not limited to, non-linearity of radio frequency (RF) transmitters, impairments in massive multiple input multiple output (MIMO) deployments, coexistence with legacy radio access technologies and densified use of the mmWave spectrum. For a mobile device to perform link adaptation and form a communication, it is required to predict its received signal to interference and noise ratio (SINR) and determine its channel quality whilst not knowing the power that is being transmitted from the wanted source or the interferers. How can it do this? This course will answer exactly that question but furthermore it will show why more advanced methods than in current mobile networks are required to do this.

This course will spend the first day looking at the issues regarding interference in a complex multiple device environment to develop a picture of the scale of the problem such that it can show simplified ways of characterising SINR. The second day of the event will focus on demonstrating traceable measurement and conformance testing solutions for SINR and also resilience to interference.

On completing this course, trainees would learn about:

1. Link adaptation and the rationale for new techniques in future communication networks.
2. Examples of link adaptation in massive MIMO systems.
3. Causes of interference in massive MIMO including non linearity, pilot contamination and mobility. 4. Traceable metrology solutions for characterising/predicting SINR

Participants are assumed to have prior knowledge of basics of array antennas, RF link budgets and matrix algebra.

About IRACON and Met5G

The European Cooperation in Science and Technology (COST) Action 15104, Inclusive Radio Communications (IRACON) concept defines the technologies aimed to support wireless connectivity at any rates, for any communicating units, and in any type of scenarios. This work is aimed towards revolutionary approaches in Radio Access technologies that will support the Wireless Internet of Things beyond 2020. Such work includes experimental research addressing Over-the-Air (OTA) testing for multiple devices, massive MIMO and mmWave technologies, where resilience to interference will be of significant importance.

The European Metrology Programme for Innovation and Research (EMPIR) 14IND10 project Metrology for 5G Communications (Met5G) has an overall objective to develop traceable metrology required by 5G communications, to improve the associated measurement uncertainties to underpin all aspects from the signals, devices, systems and test environments for the emerging 5G technologies and to provide metrological support on activities related to

standardisation for 5G. One key work package of this work includes the definition of SINR and forming traceable measurement solutions for use in future mobile networks.

Course Timetable and Descriptions of Lectures

Day 1	Day 2
0900-0955 Link Adaptation, Defining and Estimating of SINR in a (Tim Brown) • Short overview/intro to Met5G and IRACON • Link adaptation in current mobile networks • Definition of SINR • Introduction to scenarios and methods to predict SINR	0900-0955 Introduction to Traceability and Interference Measurement Solutions (David Humphreys) • Introduction to traceable measurement solutions • Reminder of SINR Characterisation • Example traceable measurements • SINR Measurement Testbed Architecture and Results
1000-1100 MIMO Precoding, Massive MIMO precoding and link adaptation using SINR (Tim Brown) • Introduction to Massive MIMO • Zero Forcing Precoding • Pilot channel estimation and contamination • Link adaptation with downlink SINR and mobility	1000-1100 Massive MIMO Testbeds (Tian Hong Loh) • Massive MIMO Testbed Architectures • Testbeds evaluations • Traceability • Measurement Setups • Example Measurement Results
1100-1130 – Coffee Break	1100-1130 – Coffee Break
1130-1230 Introduction to Non Linear RF Systems, Waveforms and Adjacent Channel Interference (Thomas Eriksson) • Introduction to non linear RF amplifiers • OFDM waveforms and intermodulation • Adjacent channel interference • Peak to average power ratio and interference	1130-1230 Measurements and prediction of non-linearity in mm-wave arrays (Koen Buisman) • Introduction to measurement techniques • Predictive measurements: Emulation load pull • Simulation: Combined EM/Circuit/Thermal techniques • Modelling and over-the-air verification thereof
1230-1330 – Lunch	1230-1330 – Lunch
1330-1425 MIMO beamforming and interference with non-linear RF systems and waveforms (Thomas Eriksson) • Revision over massive MIMO and pilot channel estimation. • Antenna arrays and side lobe level inter cell interference • Non linear effects on antenna arrays and stray patterns	1330-1425 Signalling methods towards mmWave (Tim Masson) • Classic up conversion approach • Metrology deficiencies in signalling for mmWave • Demonstration with signalling waveforms
1430-1530 Prediction of SINR (Tim Brown) • Introduction to Bit Error Rate and Error Vector Magnitude (EVM) • Prediction of SINR and Modelling with EVM.	1430-1530 mmWave Channel Sounding and interference issues (Tim Masson) • Demonstration (or simulation) of mmWave channel sounding • Wideband metrology issues

	• Multipath characteristics and interference evaluation
1530-1600 – Tea Break	1530-1600 – Tea Break
1600-1700 Massive MIMO channel measurements and characterisation of SINR (Tim Brown) • Revision of narrowband and wideband channels • Overview of measurement campaign • Post processing procedure • Evaluation of results with measured data and ability to trace • Summary of day one	Close

Modified February 2018
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