There is a general consensus that 5G wireless systems and beyond shall support a diverse set of services and communications types, including extreme Mobile Broadband, ultra-relievable Machine-Type-Communications, as well as massive-Machine Type-Communications. In addition, future air-interfaces shall support a plethora of heterogeneous and diverse applications from "virtual reality office" to "real-time remote computing" imposing a set of very challenging, and sometimes contradicting, requirements. Such requirements have been reported to include traffic volumes of up to 750Gbps/km^2, experienced end-user throughput values of several hundreds of Mbp, ultra-low latency below ms latency and reliability values of 99.999%.

Come and discuss the latest advances on 5G Air interface and how we can meet these demands at the **5G Innovation Centre, at the University of Surrey on the 22nd of February 2017**.

To register, please visit: https://www.eventbrite.co.uk/e/latest-advances-on-5g-air-interface-tickets-30491140823

Programme:

Time	Activity
9:00-9:30	Arrival and Registration
9:30-9:45	**Welcome** from Prof. R. Tafazolli, University of Surrey
9:45-10:30	***Joint-Alphabet Space Time Shift Keying for mm-Wave Non-Orthogonal Multiple Access***, Prof. Lajos Hanzo, University of Southampton
10:30-11:15	***Energy and Spectrum Efficiency Issues for mm-wave Wireless Communications***, Prof. John Thompson, The University of Edinburgh

11:15-12:00	***A Practical Channel Estimation Scheme for Indoor 60GHz Massive MIMO System***, Prof. Arumugam Nallanathan, King's College London
12:00-13:00	Lunch
13:00-13:45	***Full Duplex by means of Electrical Balance Isolation,*** Prof. Mark Beach, University of Bristol
13:45-14:30	Prof. Timothy O'Farrell, The University of Sheffield
14:30-15:15	***Enabling Extreme Resource Sharing in Future Wireless Communication Systems***, Dr Konstantinos Nikitopoulos, University of Surrey
15:15-16:00	Coffee break – Demos/Poster Session
16:00-16:45	***New Spectrally Efficient Waveform Formats and Architectures for 5G Systems and Beyond,*** Prof. Izzat Darwazeh, University College London
16:45-17:30	***MU-MIMO Technology for Inter-cell Interference Cancellation,*** Dr Yi Ma, University of Surrey
17:30-18:15	***Subband Filtered Multi-carrier Systems for Multi-service 5G Systems,*** Dr Lei Zhang, University of Surrey
18:15-18:30	Wrap up

Abstracts:

Joint-Alphabet Space Time Shift Keying for mm-Wave Non-Orthogonal Multiple Access

Panagiotis Botsinis, Ibrahim Hemadeh, Dimitrios Alanis, Zunaira Babar, Hung Nguyen, Daryus Chandra, Soon Xin Ng, Mohammed El-Hajjar, and Lajos Hanzo.

Non-Orthogonal Multiple Access (NOMA) systems are capable of achieving an increased throughput by allowing multiple users to share the same resources at the cost of a higher transmission power, or an increased detection (preprocessing) complexity at the receiver (transmitter) of an uplink (downlink) scenario. Therefore, flexible modulation schemes and smart Multiple-Input Multiple-Output (MIMO) techniques, as well as low-complexity detectors and preprocessors may become essential for efficiently balancing the performance, rate and complexity trade-off for different application scenarios. At the same time, millimeter Wave (mm-Wave) systems have a high available bandwidth and the potential to accommodate numerous antennas in a small area, which makes them an attractive candidate for 5G and future networks. In this treatise, we

propose the new concept of Joint-Alphabet Space Time Shift Keying (JA-STSK) for the uplink of NOMA mm-Wave systems. We demonstrate with the aid of EXtrinsic Information Transfer (EXIT) charts that a higher capacity is achievable when compared to STSK, while retaining the attractive flexibility of STSK in terms of its diversity gain and coding rate. Finally, we conceive quantum-assisted detectors for reducing the detection complexity, while attaining a near-optimal performance, when compared to the optimal iterative Maximum A Posteriori probability (MAP) detector.

Energy and Spectrum Efficiency Issues for mm-wave Wireless Communications

John Thompson

This talk will give an overview of recent research at the University of Edinburgh for future fifth generation wireless communications systems. There are currently major research efforts to exploit high frequency millimetre wave (mm-wave) frequency bands for cellular operation. These bands are of interest due to the wide bandwidths for 5G services but have only recently been considered due to the more hostile propagation conditions. The use of multiple antennas to perform beamforming between devices can mitigate both the channel effects and also reduce interference. In this talk we discuss techniques to improve the energy efficiency of mm-wave communications systems as power consumption of transmitter and receiver components is a major issue at these frequencies. We also discuss trade-offs in terms of energy and spectrum efficiency for beam training methods that are required to operate beamforming effectively in such systems.

A Practical Channel Estimation Scheme for indoor 60GHz Massive MIMO System

Arumugam Nallanathan, and Hamid Aghvami

As a candidate radio band for 5G mobile communications, the millimeter-wave in the range of 30–300 GHz has attracted lots of attention Specifically, 60GHz spectrum has been proposed for indoor and short-range outdoor environment , since its primary propagation paths only include the line-of-sight (LOS) and the first-order reflections . For 60 GHz mobile communications, it is possible to equip hundreds or thousands antennas at the base station (BS) due to the short wavelength, resulting in a framework called "massive MIMO". Theoretically, massive MIMO could tremendously increase the capacity and improve the energy efficiency. Meanwhile, massive MIMO offers the potential to use economic, inexpensive, and low-power components. These advantages make massive MIMO promising for the next generation wireless systems.

In this talk, a practical yet simple channel estimation scheme for 60 GHz indoor communications from antenna theory that could better explore the inherent structure of array will be presented. The physical characteristics of the massive uniform rectangular array (URA) and the decomposition of channel information into angular information and gain information will be described. The remaining channel gain information could be obtained with small amount of training resources, which significantly reduces the training overhead and the feedback cost.

Full Duplex by means of Electrical Balance Isolation

Mark Beach, Leo Laughlin, Jack Zhang, John Haine, and Kevin Morris

Since the introduction of radio it has been an article-of-faith that a station cannot simultaneously transmit and receive at the same frequency. For example, consider a smartphone; this has to transmit about half a watt of RF signal when at the cell edge at the same time as receiving a signal power of around one millionth of a microwatt – a "dynamic range" of ~120dB. Most modern cellular radio systems demand that the terminal can receive and transmit simultaneously. This is made possible by using different frequencies for uplink and downlink (to and from the base station), known as frequency-division duplexing (FDD), and means that spectrum has to be allocated in duplex-paired bands – which makes it difficult to "re-farm" existing services; and the terminal needs a highly-selective duplexing filter for every band. As there are over 30 bands allocated globally for 4G, a terminal that is usable on any band anywhere in the world is not feasible today. A technology to avoid the "duplexer farm" in mobile terminals (see right), and potentially allow division-free duplexing for future systems, is highly desirable. A number of research teams in academia and industry are investigating methods to achieve this across the world. These are based on some combination of using separate antennas, various circuits that can separate signals based on their direction of transmission such as circulators or directional couplers, and signal cancellation.

Recent research at Bristol has focused on the use of hybrid transformers as these have broader bandwidth than circulators, do not require bias magnets, and can be integrated on-chip. However, to optimise performance the hybrid needs a balance impedance that is accurately matched to the antenna, which makes the system potentially vulnerable to detuning of the antenna by proximity to objects such as the user's hand, and reflections from nearby objects in the environment. In mobile applications, the latter may be moving very rapidly. This presentation will provide a brief overview in four key areas, novel low-complexity algorithms for deriving the balancing coefficients, novel cancellation methodology for the residue self-interference, application of non-linear digital cancellation as well as results from extensive field trials using the Bristol based NI VST demonstrator.

Enabling Extreme Resource Sharing in Future Wireless Communication Systems

Konstantinos Nikitopoulos, George Georgis, Christopher Husmann, Farhad Mehran, Chatura Jaywardena, Kyle Jamieson, Hamid Jafarkhani, and Rahim Tafazolli

5G and future local area wireless communication systems shall be able to support very high peak user and network rates as well as very large numbers of connected devices, while keeping the latency requirements at very low levels. These needs have triggered a paradigm shift from orthogonal to non-orthogonal signal transmissions that enable extreme sharing of the available resources, including frequency and time. Such schemes include multi-antenna (MIMO) deployments for aggressive spatial multiplexing, as well as non-orthogonal multiple access schemes. In practice, to deliver the theoretical gains of such large non-orthogonal schemes, the mutually interfering information streams must be efficiently demultiplexed. In this direction, and to keep detection complexity low, large and massive MIMO systems typically employ linear detection schemes, which however, can provide near-optimal performance only when the number of users is much smaller than the number of access-point or base-station antennas, leaving a large portion of the MIMO channel capacity unexploited. Alternatively, maximum-likelihood (ML) detection schemes, allow to efficiently demultiplex as many mutually interfering information streams (e.g., spatially multiplexed users) as the number of the observed signals (e.g., base-station antennas). However, the processing requirements of ML detection increase exponentially with the number of mutually interfering information streams, exceeding the processing capabilities of traditional processors. Here we present MultiSphere; the first method to massively parallelize the ML detection problem in a nearly-independent manner, without compromising the maximum-likelihood performance, and by keeping the overall processing complexity at the levels of highly-optimized sequential sphere decoders. We also present FlexCore, an approximate version of MultiSphere that is orders of magnitude more efficient than state-of-the-art parallel, approximate ML detection schemes, and the first approach able to decode in real-time all the LTE rates using commodity GPU boards. Finally, we introduce the concept of Space-Time Super-Modulation according to which additional low-rate and highly reliable information can be transmitted on top of traditionally modulated and space-time encoded information, without increasing the transmitted block length or degrading their error-rate performance. We show that Space-Time Super-Modulation can be efficiently used in the context of machine-type communications to enable joint medium access and rateless data transmission while reducing or even eliminating the need for transmitting preamble sequences.

New Spectrally Efficient Waveform Formats and Architectures for 5G Systems and Beyond

Izzat Darwazeh, John Mitchell, and Christos Masouros

Over the past 15 years we have been developing non-orthogonal signal formats that can save spectrum by compressing the spacing between sub-carriers, below the orthogonality limit. The proposed waveforms are derived from an existing non-orthogonal multicarrier concept termed spectrally efficient frequency division multiplexing (SEFDM) where sub-carriers are non-orthogonally packed at frequencies below the symbol rate. This improves the spectral efficiency at the cost of self-created inter carrier interference (ICI) and therefore some “ tolerable” power penalty and added receiver complexity. We have reported experiments carried out for three scenarios including long term evolution (LTE)-like wireless link, millimeter wave radio-over-fiber (RoF) link and optical fiber link. In the first scenario, for a given 25 MHz bandwidth, the SEFDM testbed can provide 70 Mbit/s gross data rate while only 50 Mbit/s can be achieved for an OFDM system occupying the same bandwidth. For the millimeter wave experiment, occupying a 1.125 GHz bandwidth, the gross bit rate for OFDM is 2.25 Gbit/s and with 40% bandwidth compression, 3.75 Gbit/s can be achieved for SEFDM. Two experimental optical fiber links will be described; a 10 Gbit/s direct detection optical SEFDM system and a 24 Gbit/s coherent detection SEFDM system. The LTE-like signals and millimeter wave technologies are well suited to provide last mile communications to end users as both can support mobility in wireless environments. The lightwave signals delivered by optical fibers would offer higher data rates and support long-haul communications. The reported techniques, used individually or combined, would be of interest to future wireless system designers, where bandwidth saving is of importance.

MU-MIMO Technology for Inter-cell Interference Cancellation

Yi Ma

Inter-cell interference is challenging the development of future wireless networks with specific to the ambition of capacity delivery. One of potential technologies to handle this challenge is MU-MIMO, which utilizes spatial degrees of freedom to cancel the inter-cell interference. However, practical implementation of MU-MIMO faces additional challenges of signal processing scalability. (Near-) optimal multi-antenna processing techniques are computationally too expensive, and low-complexity linear techniques are often too sub-optimal in performances. In this presentation, we will introduce a couple of physical layer approaches recently developed within the 5GIC (University of Surrey), which promise to deliver the scalability as per 5G need. More specifically, a hybrid modulation scheme, named AQAM, will be introduced to scale up conventional MU-MIMO communications for both the uplink and downlink. Moreover, we will also talk about a low-complexity nonlinear multi-antenna precoding technique, named DxVP, which is able to provide near-optimal downlink performances at the cost of comparable computational complexity with the linear MIMO precoding. Our technical discussion will be mainly based on a 1-D multi-cell communication model assuming either full or partial cooperation between base-stations. The tradeoff between backhaul load and the performance of interference cancellation will also be discussed.

Subband Filtered Multi-carrier Systems for Multi-service 5G Systems

Lei Zhang, Ayesha Ijaz, Pei Xiao, Atta Quddus, and Rahim Tafazolli

Enhanced mobile broadband (eMBB), massive machine type communications (mMTC) and ultra-reliable and low latency communications (URLLC), have been categorized as three main communication scenarios for the 5-th Generation (5G) wireless communication and beyond. To flexibly support diverse communication requirements (e.g., throughput, latency, massive connection, etc.) for 5G, one viable solution is to divide the system bandwidth into several service subbands, each for a different type of service. However, the solution may result in a significant inter service band interference (ISBI). In this presentation, a framework for multi service (MS) systems is established based on universal filtered multi-carrier (UFMC) system. The system model is derived by taking the ISBI into account, followed by a number of properties on ISBI to give the guideline for 5G system design. In addition, we present low-complexity ISBI cancelation algorithms in downlink transmission to improve the MS system performance. Numerical analysis shows the proposed ISBI cancelation and equalization algorithms can significantly improve the system performance.