A joint event from the Small Cell and Radio Technology SIGs

'Technology Enablers for 5G Spectrum Sharing'

21st October 2019

Hosted by Digital Catapult and sponsored by Plum Consulting

The **Small Cell SIG** is championed by Simon Fletcher of **Real Wireless**, Caroline Gabriel of **Rethink Technology Research**, Neil Piercy of **ip.access** and Simon Saunders of **Google.**
The **Radio Technology SIG** is championed by Mark Beach of **University of Bristol**, Brian Collins of **BSC Associates,** Peter Relph of **PA Consulting Group,** Dr Vidhya Sridhar of **TTP Group** and Peter Topham of **Qualcomm Technologies International**

Venue: Digital Catapult, 101 Euston Road, London NW1 2RA

AGENDA

09:30	Registration and networking
10:00	Welcome from **Simon Mead, CEO, CW (Cambridge Wireless)**
10:05	Welcome from **Dritan Kaleshi, Head of Technology (5G), Digital Catapult**
10:10	Welcome from **Ian Corden, Director, Telecommunications,** at event sponsor, **Plum Consulting**
10:15	**Session chaired by Mark Beach, Radio Technology SIG Champion** **Making spectrum work better for consumers and businesses** **David Harrison, Principal Advisor Digital Media Technology, Ofcom** Spectrum sharing provides opportunities to support innovation in new wireless services and to extend their reach into more places where people and things go. In this talk David will explore how these benefits can be best secured, including the future role of technology.
10:35	**Q & A**
10:40	**The U.S. 3.5 GHz Citizens Broadband Radio Service** **Andy Clegg, Spectrum Engineering Lead, Google** Initial commercial CBRS deployments have begun in the U.S., and full commercial service will begin later this year. The sharing arrangements in CBRS, involving Spectrum Access Systems (SASs) and Environmental Sensing Capability (ESC) networks, are relatively complex, driven mostly by the dynamic and secret nature of military incumbent activities and the need to compute aggregate interference into incumbents and some CBRS users. This talk will explore a few of the many technical details of the protection framework and how the SAS and ESC systems operate, with the goal of raising awareness for potential application of some of the CBRS concepts in other bands and other regions.
11:10	**Q & A**
11:15	**Advancing the Understanding of Sharing in 5G Networks** **Dr Tim Forde, Executive Director of CONNECT, Trinity College Dublin** In this talk Tim will describe advances the CONNECT research centre has made in understanding limits of spectrum and infrastructure sharing. He also describes some recent work undertaken in collaboration with industry partners which looks at how we can overcome unforeseen practical limitations of sharing in urban small cell deployments.
11:35	**Q & A**
11:40	Refreshments and networking
12:10	**Session chaired by Simon Saunders, Small Cell SIG Champion** **Co-existence in an age of technology neutrality and licence-exemption** **Simon Pike, Independent** Much of modern spectrum management is based on an implicit assumption that the applications that share a particular portion of spectrum will have broadly similar characteristics and deployment. However, the ever-widening range of uses of the radio spectrum means that this is often no longer the case. A similar situation arises when licence-exempt spectrum is used in novel ways. An example of this is the 60GHz band. Does the approach to studying coexistence need to change, or are we heading towards increasing problems of interference between dissimilar applications? Simon will suggest a possible approach to mitigate this interference, by recommending 'default' frequencies to be used by an application in the absence of other users or interference. The 'default' frequency would be different for different applications, which would reduce 'clashes' between different types of use.

12:30	**Q & A**
12:35	**Signal Processing Techniques for Mitigating Against Non-System Interference** **Stephen Wales, Roke Manor Research** In spectrum sharing applications co-channel interference from a different system could be experienced, and normally co-ordination rules are developed that set interference levels to minimise impact on both systems involved in sharing. These interference levels can be quite restrictive. Interference mitigation techniques can potentially be incorporated into receivers allowing higher levels of interference to be tolerated. This talk examines a number of signal processing techniques designed to mitigate against non-system interference. These techniques exploit differences in signal characteristics between the wanted signal and interference. Examples covered include transform domain excision, signal separation based on statistics, array processing techniques and an approach based on machine learning. Examples of equipment incorporating some of the techniques described are given.
12:55	**Q & A**
13:00	Lunch and networking
14:00	**Session chaired by Brian Collins, Radio Technology SIG Champion** **Flexible RF technologies for Spectrum Sharing** **Mark Beach, Professor of Radio Systems Engineering, University of Bristol** Increasingly, networks are moving to being software defined, making them highly flexible and independent of their transmission and computing substrate. However, this is not true for the radio interface: current systems are inflexible and unable to easily adapt to new standards, spectrum and the efficient support of Dynamic Spectrum Access. In this presentation, the latest laboratory results from Bristol's research in flexible duplexing, robust receiver architectures and efficient and agile transmitter technologies will be summarised in the context of spectrum sharing.
14:20	**Q & A**
14:25	**RF Hardware Challenges in Cognitive Radios** **Martin Gostling, Managing Director, Radio Design** State of the art cellular radios contain fixed frequency components – for example filters – that pose a significant challenge to the cognitive radio concept due to their lack of adaptability. This talk analyses some of these problems and presents potential solutions.
14:45	**Q & A**
14:50	**Massive MIMO and centralised RANs for spectrum sharing** **Ian Corden, Director, Telecommunications, Plum Consulting** Massive MIMO has been widely cited as a key technology with 5G mobile solutions and continues to be an active area in both research and product development domains, with promise of significant capacity and coverage extensions over SISO and low order MIMO systems. However, in mobile environments with highly variable and dynamic radio scattering conditions, the channel estimation problem is non-trivial, yielding degradation of performance in practical situations over theoretical estimates and lab results. Further, high order MIMO designs require high bandwidth backhaul connections. In parallel, RAN architectures are being reconsidered. With new open access protocols such as eCPRI, radio antenna arrays can be separated from baseband processing hubs and control plane systems using ethernet over fiber links, enabling centralised architectures which can support diverse MIMO and beamforming. This talk will review the current state of massive MIMO in mobile systems, the potential for MIMO evolution with centralised RANs, the potential for these technologies to support spectrum sharing, and the potential system and industry advantages.
15:10	**Q & A**
15:15	**Panel session to be chaired by Neil Piercy, Small Cell SIG Champion**
15:40	**Wrap-up by SIG Champion**
15:45	**End of session followed by refreshments and networking**
16:30	**Event closes**

With the permission of the speakers, presentations will be loaded to the CW website on the day following the event

Profile of organisers

Cambridge Wireless (CW)
CW is the leading international community for companies involved in the research, development and application of wireless and mobile, internet, semiconductor and software technologies. With over 400 members from major network operators and device manufacturers to innovative start-ups and universities, CW stimulates debate and collaboration, harnesses and shares knowledge, and helps to build connections between academia and industry. CW's 19 Special Interest Groups (SIGs) provide its members with a dynamic forum where they can network with their peers, track the latest technology trends and business developments and position their organisations in key market sectors. CW also organises major conferences and start-up competitions along with other high-quality industry networking events and dinners. With headquarters at the heart of Cambridge, UK, CW partners with other international industry clusters and organisations to extend its reach and remain at the forefront of global developments and business opportunities. **cambridgewireless.co.uk**

Profile of host

Digital Catapult
Digital Catapult is the UK's leading advanced digital technology innovation centre, driving early adoption of technologies to make UK businesses more competitive and productive and grow the country's economy. We connect large established companies, startup and scaleup businesses and researchers to discover new ways to solve big challenges in the manufacturing and creative industries. Through this collaboration businesses are supported to develop the right technologies to solve problems, increase productivity and open up new markets faster. Digital Catapult provides physical and digital facilities for experimentation and testing that would otherwise not be accessible for smaller companies. As well as breaking down barriers to technology adoption for startups and scaleups, our work de-risks innovation for large enterprises and uncovers new commercial applications in immersive, future networks, and artificial intelligence technologies. **digitalcatapult.org.uk**

Profile of sponsor

Plum Consulting
Plum is a leading independent consulting firm, focused on the telecommunications, media, technology, and adjacent sectors. We apply extensive industry knowledge, consulting experience, and rigorous analysis to address challenges and opportunities across regulatory, radio spectrum, economic, commercial, and technology domains. Much of our work is driven by the changes resulting from various aspects of convergence. Our strengths are the ability to understand market evolution, analyse and synthesise what changes mean and to create solutions for our clients that are simple and practical. Plum works for players across the value chain including equipment vendors, network operators / service providers, content players and government / regulatory organisations. **plumconsulting.co.uk**

Profile of Small Cell SIG Champions

Simon Fletcher, Real Wireless
Simon joined Real Wireless in January 2016 as Chief Technology Officer, taking overall technical responsibility across the company. Recognised as a regular speaker at industry events and currently acting as chairman of the CW Future of Wireless Conference Organising Committee and Small Cell SIG Champion, Simon brings an enviable network of contacts to Real Wireless alongside a proven ability to lead teams in delivering technical projects while identifying and meeting new strategic goals for the wider business. His long-standing association with the UK innovation eco-system as a director of mVCE and the Innovate-UK ICT-KTN brings a wealth of knowledge on the application of strategic research through open innovation to accelerate product and services delivery. In recent times his focus has been on future cities, the application of 5G and IoT in industry verticals with an event horizon towards 2030. Simon spent the past 20 years working in the design and development of technical telecoms infrastructure. Beginning his career in technology demonstrators at Racal Radar Defence Systems, he moved to Telecoms Modus in 1999 to play a key role in the development of 3G products and in 2006 he established a core architecture team that helped develop the first-generation of technology for 4G systems culminating in a Steering Board position in the LTE SAE Trials Initiative (LSTI), a global forum with a mission to assure the early adoption of LTE. His long participation in Common Public Radio Interface (CPRI) defining early C-RAN concepts brings great foresight on an important architectural element of emerging 5G architectures. **real-wireless.com**

Caroline Gabriel, Rethink Technology Research
Caroline has been engaged in technology analysis, research and consulting for 30 years and since 2002, has been focused entirely on mobile and wireless. As co-founder and research director of Rethink Technology Research, Caroline has developed a significant research base and forecast methodology, based around deep contacts with mobile and converged operators round the world. This addresses critical issues and trends in mobile and wireless infrastructure, and particularly operator deployment intentions for 4G, 5G, small cells, Cloud-RAN and other technologies. She is also a senior contributor to Analysys Mason's Next Generation Wireless research programme. She has led research and consulting projects with a wide range of clients, including mobile infrastructure vendors, large and start-up operators, regulators, trade bodies, government agencies and financial institutions. Her advice and forecasts have helped inform strategic decisions at a wide range of vendors, operators, start-ups and finance houses. Prior to setting up Rethink, Caroline held various executive positions at VNU Business Publishing BV, then Europe's largest producer of technology related B2B reports and publications. She was the European content and research director, and was a member of the leadership team for VNU's online business. She holds an MA from the University of Oxford. **rethinkresearch.biz**

Neil Piercy, ip.access
Neil has been developing base stations for various communications systems for over 25 years, during which time he has performed roles throughout the whole development lifecycle as well as management roles. He joined ip.access as a small cell System Architect when the company was in its infancy in 2000, and has since designed GSM, UMTS and LTE small cell RAN equipment and systems. His specialist areas include security and networking, as well as a focus on all aspects of protocol design and implementation, and on system performance and simulation. Now as Head of Research he is responsible for ip.access future products and technologies. He is an active member of the Small Cell Forum, a Champion for their work on the Virtualisation of small cells. He is currently a representative for the EU project SESAME on the 5GPPP Architecture group. **ipaccess.com**

Simon Saunders, Google
Simon is a specialist in the technology of wireless communications, with a technical and commercial background derived from senior appointments in both industry (including Philips and Motorola) and academia (University of Surrey). He is an adjunct professor at Trinity College Dublin and Access Technology Principal at Google. As co-founder and Director of Technology for independent wireless strategy advisory firm Real Wireless, he was responsible for overall technical capability and direction, providing independent wireless expertise and advice to operators, regulators, technology and law firms and wireless users. Customers included Ofcom, Cisco, European Commission, Virgin Media, TalkTalk, Inmarsat and many others. He is an author of over 150 articles, books and book chapters. He has acted as a consultant to companies including BAA, BBC, O2, Ofcom, BT, ntl, Mitsubishi and British Land and was CTO of Red-M and CEO of Cellular Design Services Ltd and has acted as an expert witness in legal proceedings in England and the US. Simon speaks and chairs a wide range of international conferences and training courses and has invented over 15 patented wireless technologies. Particular expertise includes in-building wireless systems, radiowave propagation prediction, smart antenna design and mobile system analysis. He has served on technical advisory boards of several companies, was Visiting Professor to the University of Surrey, member of the industrial advisory board at University College London, founding chairman of Small Cell Forum (formerly Femto Forum), which he chaired from 2007-12 and a member of the Ofcom Spectrum Advisory Board from 2007-14. **google.co.uk**

Profile of Radio Technology SIG Champions

Mark Beach, University of Bristol (Communication Systems & Networks Research Group)
Mark Beach received his PhD for research addressing the application of Smart Antenna techniques to GPS from the University of Bristol in 1989, where he subsequently joined as a member of academic staff. He was promoted to Senior Lecturer in 1996, Reader in 1998 and Professor in 2003. He was Head of the Department of Electrical & Electronic Engineering from 2006 to 2010, and then spearheaded Bristol's hosting of the EPSRC Centre for Doctoral Training (CDT) in Communications. He currently manages the delivery of the CDT in Communications, leads research in the field of enabling technologies for the delivery of 5G and beyond wireless connectivity, as well as his role as the School Research Impact Director. Mark's current research activities are delivered through the Communication Systems and Networks Group, forming a key component within Bristol's Smart Internet Lab. He has over 25 years of physical layer wireless research embracing the application of Spread Spectrum technology for cellular systems, adaptive or smart antenna for capacity and range extension in wireless networks, MIMO aided connectivity for through-put enhancement, Millimetre Wave technologies as well as flexible RF technologies for SDR modems underpins his current research portfolio. **bristol.ac.uk/engineering/research/csn/**

Brian Collins, BSC Associates
Brian has designed antennas for applications including radio and TV broadcasting, base stations, handsets and consumer products, and has operated his own consultancy firm for the last 12 years. He has published more than 70 papers on antenna topics and contributed chapters to several recent textbooks. He operates a small consultancy company, chairs the Antenna Interface Standards Group and is an Honorary Visiting Professor in the School of Electronic Engineering and Computer Science at Queen Mary, University of London. **bscassociates.co.uk**

Peter Relph, PA Consulting Group
Peter Relph has worked in the wireless industry for 30 years and spent the last 22 years as a radio systems engineer with PA Consulting Group. He originally graduated from UCL in Electronics with Optoelectronics and since then has decreased his operating frequency, working on mm-wave radar systems at Philips Research, then a broad range of industries and applications with PA. His recent focus has been on cellular systems wider experience with satellite, Wifi, modern IoT and bespoke communications systems. Professional interests range from propagation modelling, RF system design and physical layer processing. **paconsulting.com**

Dr Vidhya Sridhar, TTP Group
Vidhya Sridhar is a consultant at The Technology Partnership (TTP) Plc. She has a background in digital signal processing and physical layer design and development. In her PhD at Imperial College London, she carried out research on array signal processing techniques with applications in 5G and defence. Prior to her PhD, she spent three years working on physical layer design and development in LTE and WiMAX at Broadcom (India) and Alcatel Lucent (India) respectively. **ttp.com**

Peter Topham, Qualcomm Technologies International
Peter has more than 30 years' experience of RF and high-speed circuit design, taking chips into production ranging from FM Band II through cellular, Bluetooth and on to UWB at 10GHz. He has been with Qualcomm for 7 years, specialising in low-power RF design for portable and wearable products. **qualcomm.com**

Profile of speakers

Mark Beach, University of Bristol (Communication Systems & Networks Research Group)
Profile above.

Andrew Clegg, Google
Andrew Clegg is Spectrum Engineering Lead for Google. He is presently focused primarily on identifying spectrum sharing opportunities for commercial wireless networks. Prior to joining Google, he served as the spectrum manager for the U.S. National Science Foundation, where he founded the Enhancing Access to the Radio Spectrum (EARS) program, a $50 million program dedicated to funding academic and small business research focused on improving spectrum efficiency and access. Prior to NSF, he was a Lead Member of Technical Staff at what is now AT&T Mobility. He has over 20 years' experience in national and international spectrum management for both government and commercial applications, and was a member of the U.S. delegation to two World Radiocommunication Conferences. He holds a PhD in Radio Astronomy and Electrical Engineering. **google.com**

Ian Corden, Plum Consulting
Ian is a Director at Plum, bringing over 25 years of experience in industry and consulting within telecoms and technology. He is passionate on the application of emerging technologies, engineering, and innovation for the development of commercial, economic, and social value. He specialises in the intersects on strategy and transformation, technology, engineering, and architecture, and policy and regulation, with a particular focus towards development and delivery of practical commercial solutions, underpinned by robust analysis and proven experience. Ian's work has been used by governments and regulators to inform on policy development and implementation, and by operators, vendors, investors, and law firms in regulatory, commercial, and technology strategy development and solutions delivery. Solutions delivered for clients have included 5G strategy and programme development for a major Asian enterprise, 5G spectrum review influencing national government policy for a leading UK industry body, quality review of a wholesale local access regulatory price control model for a major European regulator, c. £10m capex saving on a major IP network implementation programme for a European telco, spectrum auction valuation advice for a European mobile operator, and valuation advice to the board of a European telco on disposal of a key business unit. During the early part of his career, he worked in defence systems and digital mobile radio and was awarded the Bell Labs President's Prize for R&D and product development at Bell Labs NJ USA. Ian holds PhD and BSc (1st Class Hons, IET Prize) degrees in Telecommunications and Electronic Engineering, plus PgD in Management and Finance, UK Chartered Engineer, Fellow IET, and is Vice-Chair of the techUK Communications Infrastructure Council. **plumconsulting.co.uk**

Tim Forde, Trinity College, University of Dublin @timkforde
Tim Forde is Executive Director of the CONNECT Research Centre for Networks and Communications, Ireland's leading telecommunications research centre. He is responsible for delivering the strategic vision for operations, industry and stakeholder engagement, as well as ensuring the smooth management of the Centre. He has a PhD in wireless networking from Trinity College, Dublin and his postdoctoral studies focused on the use of behavioural economics in the design spectrum markets. He has recently worked for the European Commission conducting studies on 5G and spectrum sharing. **connectcentre.ie**

Martin Gostling, Radio Design
Martin has been at Radio Design from its inception in 2007 and now holds the position of Managing Director. Previously, he had responsibility for the company's technical strategy, regularly advising operators on network sharing options and cell site optimisation whilst overseeing the company's product and patent portfolios. Martin received a First Class MA in Mathematics and a Masters of Mathematics from Cambridge University followed by a PhD from Leeds University. He subsequently moved to Filtronic where he worked as a System Engineer on base station RF modules before joining Radio Design. **radiodesign.eu**

David Harrison, Ofcom
David is Director of Spectrum Technology in Ofcom. At Ofcom he has led technical research and supporting Ofcom policy development across a wide range of topics including: the internet of things, fixed and mobile availability and performance, unlicensed Wi-Fi spectrum, future use of UHF spectrum, network neutrality and next generation broadband access. Before joining Ofcom, David worked for the Independent Television Commission where he held the position of Deputy Director of Technology, and before that he led the high frequency research and development activities in Thomson Multimedia based in Rennes. David holds a degree and PhD in Electrical and Electronic Engineering. **ofcom.org.uk**

Simon Pike, Independent
Simon Pike has worked in the mobile industry for more than 25 years. For fifteen years up to 2016, he was Chief Engineer, Regulatory and Spectrum for Vodafone Group, which he represented in UK, European and global meetings on radio spectrum management, mobile technology and standards. He has been Chair of groups in ITU (WRC-03), CEPT, ETSI (SMG8 and TFES) and Spectrum Policy Forum (Cluster 4). For the last year up to June '18, Simon was a 5G Adviser in DCMS, focussing on supporting policy for rail passenger connectivity. Immediately prior to this meeting, he will be giving a presentation on '5G: The Vision, the Reality and the Future' at the International Broadcasting Convention (IBC 2018) in Amsterdam.

Stephen Wales, Roke Manor Research
Stephen Wales has worked in Industrial Research and Development for Roke Manor Research on wireless communications covering mobile, satellite and defence applications. His expertise lies in the design of the physical layer and signal processing applied to wireless systems. He has contributed to 3GPP standards and has performed numerous studies relating to wireless communication across industry and Government. He has researched and developed a number of interference cancellation techniques applicable to mobile and defence applications. He currently leads the wireless communication capability at Roke Manor Research. **roke.co.uk**