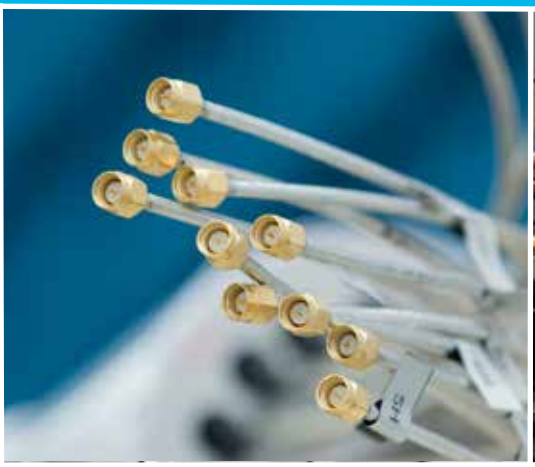
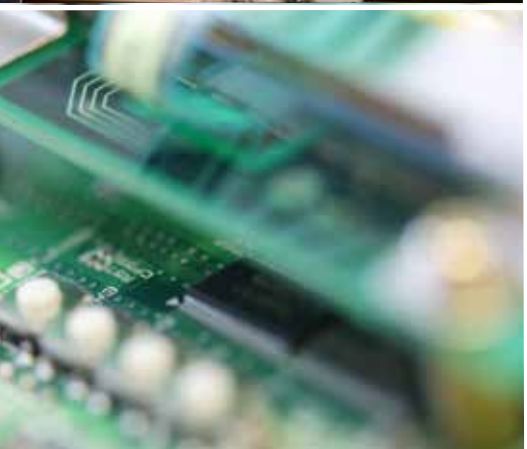
University of BRISTOL

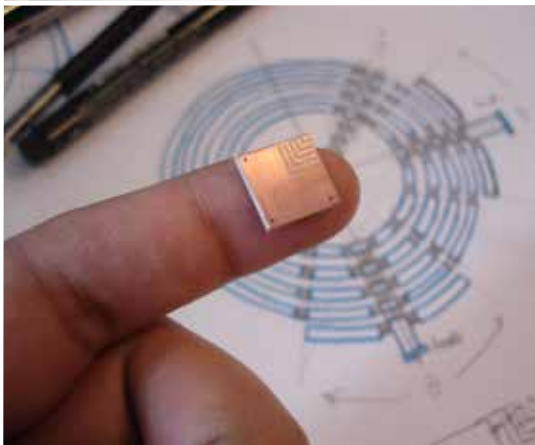
EPSRC
Engineering and Physical Sciences Research Council

EPSRC Centre for Doctoral Training in Communications

Annual Report 2014





Foreword

It is with great pleasure that we bring you the latest Annual Report from the EPSRC Centre for Doctoral Training in Communications.

Since the launch in 2011, our CDT has recruited four intakes, with a total of 39 students now studying in the Centre. The first cohort are now close to completing their PhDs, having made significant contributions worthy of publication in leading journals, key international conferences and public demonstrations of their research. They are combining time for writing up their PhDs with considering their career options.

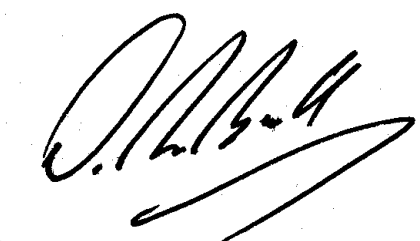
At the other end of the spectrum, the fourth cohort are concentrating on pursuing the first year taught units before commencing their research projects this summer.

In 2014, we were delighted that Dr Howard Benn of Samsung R&D was the guest speaker for our Annual Public Lecture, where he spoke to a large audience on the subject of 'Millimeter Wave as a Key New Element in 5G Cellular Networks'. A very successful Annual Student Research Conference was held at M Shed in Bristol on the following day.

In August, Dr Simon Armour was appointed as Taught Programme Director following the previous officeholder, Dr Kevin Morris, becoming Head of the Department of Electrical & Electronic Engineering.

We are grateful for the ongoing support from EPSRC and our industrial partners. Their engagement has been particularly important, not only in providing relevant and challenging research projects, but also in providing complementary skills training and new equipment facilities.

I hope this report will give you an insight into the personalities and the activities associated with our Centre over the past year. Please enjoy reading it and do not hesitate to get in touch if you would like to discuss anything in more detail.



Professor David Bull
Director, EPSRC Centre for Doctoral Training in Communications

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Recruitment

"Bristol is an amazingly vibrant city to live, and the University of Bristol a great place to be a postgraduate student."

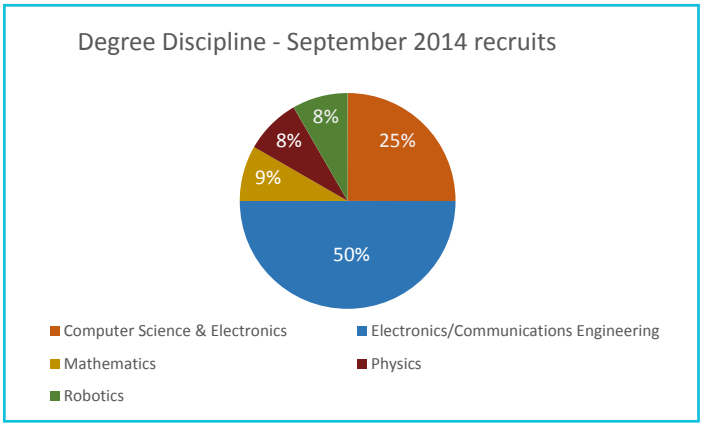
Giovanni Ciurleo, Student

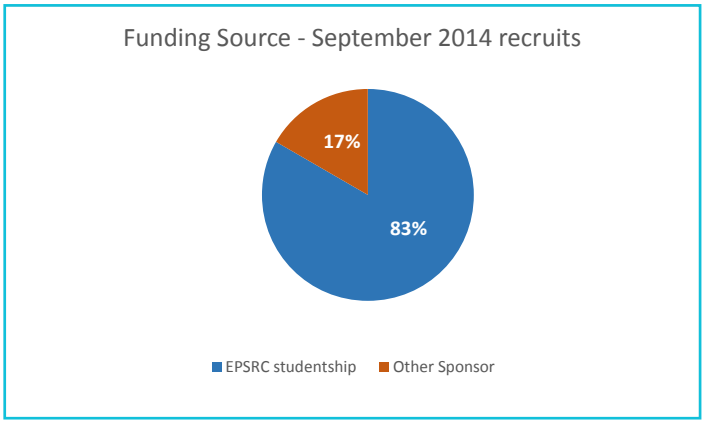
In September 2014, the Centre was pleased to welcome the latest cohort of 12 postgraduate students to join the programme. Ten students are directly funded by EPSRC (Engineering and Physical Sciences Research Council) with additional support from industry providing enhanced stipends. Two students are funded via scholarships from their own overseas governments. The additional funding from industry has been provided to ensure that we recruit the best students.

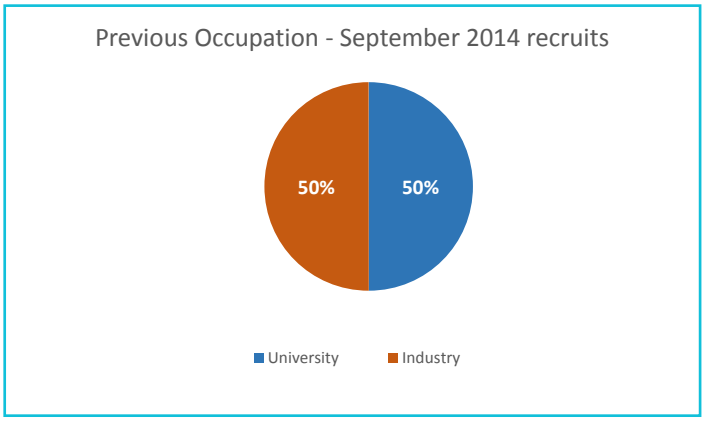
Students have been recruited from a wide range of relevant engineering and science academic disciplines (see the charts opposite), and will benefit from enhancing their academic knowledge with the technical and broadskills training provided in the taught and research years.

As in previous years, the Centre had a very selective recruitment policy; recruiting the highest calibre students with a first degree in Electrical & Electronic Engineering, Mathematics, Physics or Computer Science. Students receive training in cutting-edge engineering technology and have access to a wide range of transferable skills training to ensure they will be high employable in either industry or academia. They will also develop strong mathematical skills to apply to Communications challenges.

We were also very successful in recruiting individuals returning to education following a period working in industry who wished to enhance their skills to improve their employment prospects.







"The programme provided me with a great opportunity of working towards a PhD while at the same time enriching my knowledge base as well as establishing contacts with industry."

Odysseas Pappas, Student

Taught Phase

Taught Units

The first year of the programme has been designed to provide students with a wide range of fundamental background knowledge to develop their core skills in mathematics and comunications engineering. Students are required to take compulsory units and are also able to pursue their interests in particular topics through the selection of optional units. Comments on unit choice from the previous cohort were taken into account when deciding which optional units the cohort would be able to select from.

In addition, students are required to take a unit in Enterprise & Innovation, participate in a group project and an individual research project.

Enterprise

Mr Greville Commins, Entrepreneur in Residence at the University, led the bespoke Enterprise Unit. Students received training from experts in the field who also worked in the Communications industry, and were required to provide a detailed analytical report on a realistic case study on a business drawn from the communications sector. They also presented a 'pitch' on why they would or would not invest in the company.

Individual Research Project

All students undertook an individual research project during the summer. In many cases the projects were on topics proposed and sponsored by industry, with mentoring and financial support being provided. The projects formed the basis for the PhD project in the research phase.

Group Project

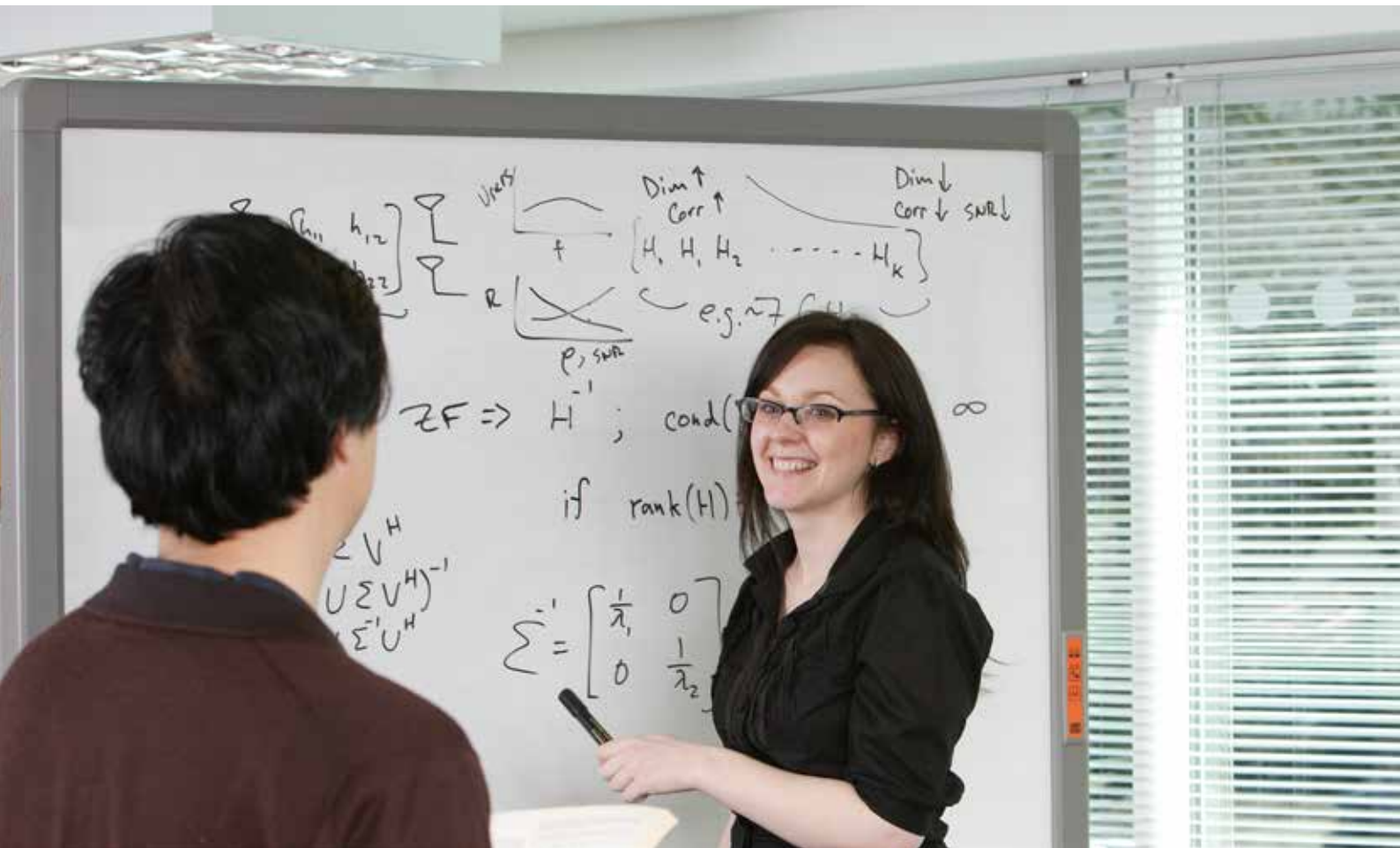
Ofcom have continued their support of this activity, drilling deeper into the realms of white space wireless access.

The rich skills mix of the cohort has again yielded a broad, but in depth analysis and contribution to this evolving access methodology.

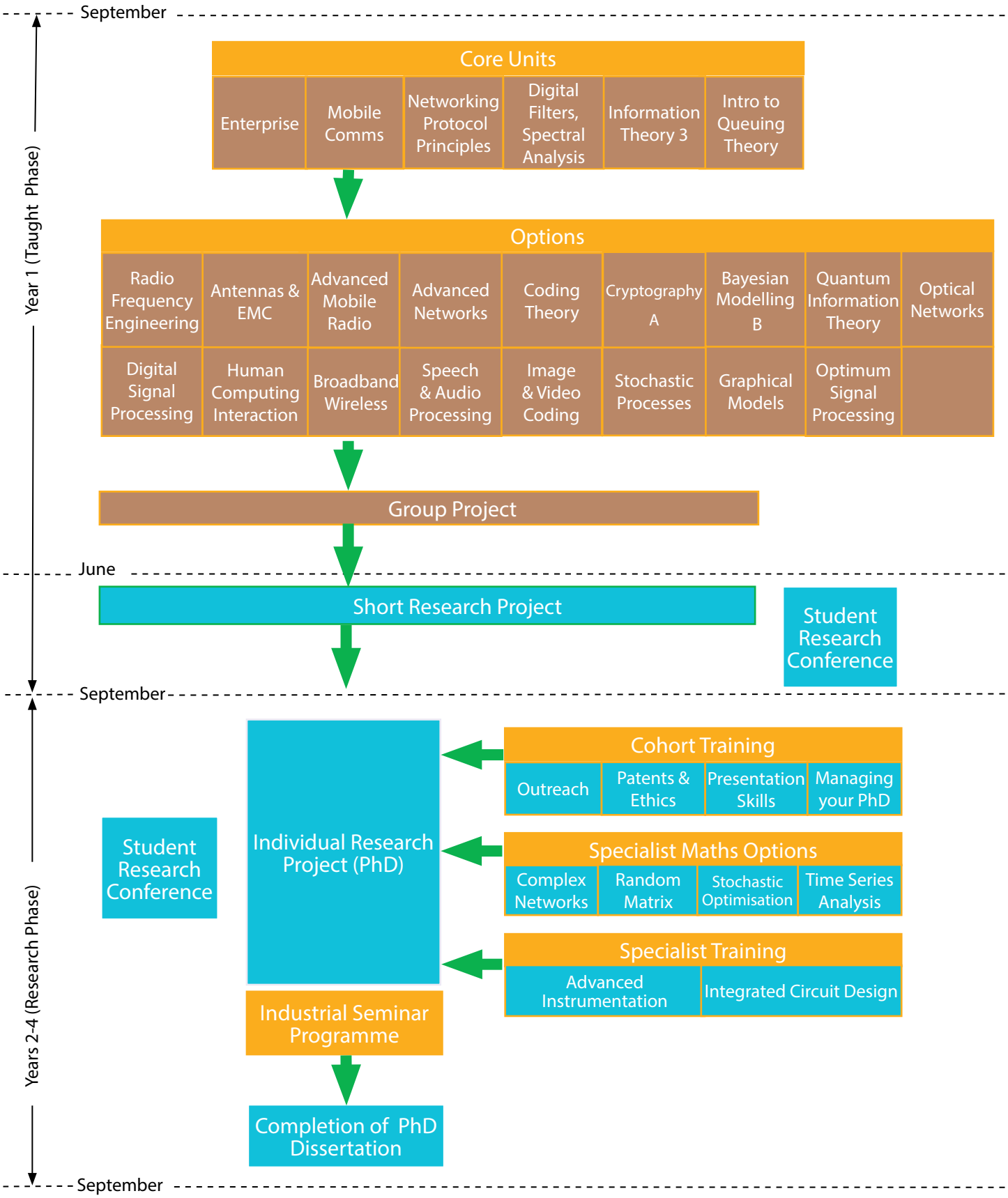
Dr Gary Clemo (Ofcom) spent time in Bristol with our students specifying the research and business case challenge as well as the final assessment of their work.

"The taught first year allows a chance to learn about the core challenges in the Communications disciplines and has helped me to determine how my knowledge and skills may be best applied in the field."

Jonathan Weissman, Student



Programme Specification



Research Highlights

Over the last 12 months students have conducted research on a broad range of topics ranging from biologically inspired vision systems to RF amplifiers. Students are integrated into the relevant research groups across Engineering and Science to ensure that they gain maximum access to academics and fellow researchers, equipment and seminars. Examples of the research undertaken is detailed below. Students in all research years have presented at conferences, seminars and published in journals.

Most research has been sponsored by industry, who have also provide mentors to give technical advice to students. Support has also be provided through EU and EPSRC research grants.

Paul Worgan has been working with the Sensor Platform for Healthcare in a Residential Environment (SPHERE) project to investigate the human factors influencing the inductive power transfer to health care wearables and how to make on-body inductive power transfer receive coils more sociably acceptable and comfortable to wear.

Chris Waters has spent the first year of his research project investigating methods to perform interference alignment through information theoretic frameworks. He has built a simulation platform to tackle the obstacles that interference alignment, enabled through MIMO, will meet in coming to market.

George Margelis has continued exploring his interest in the IoT-related wireless technologies by creating an Evaluation Board for Sigfox communications and studies on the technology modelling and BER performance in wireless channels employing Random Phase Multiple Access channel accessing scheme.

Brett Hosking has been completing the final stages of his research on enhanced spatial resampling for video compression and better video compression performance at low bitrates before writing up his thesis.

Peter Bagot spent several weeks at the Universitat Politecnica de Valenica with the iTEAM gaining access to their simulation and hardware tools enhancing his research on adaptive digital TV broadcast. This secondment lead to a series of conference papers.

Paul Harris has made significant contributions to the hardware integration & software configuration of the Massive MIMO test-bed, which is part of the Bristol Is Open (BIO) living city lab. Paul will extend the hardware and signal processing algorithms such that the system can be deployed in a distributed configuration rather than a single 128 element system.

Leo Laughlin has driven forward his research on Full Duplex, taking theory to the laboratory demonstrator operating between 800MHz to 2GHz as well as continuing to publish widely in both journal and conferences. Several undergraduate and MSc students have also worked alongside Leo, contributing to the research activity as well as giving them a real taste of research.

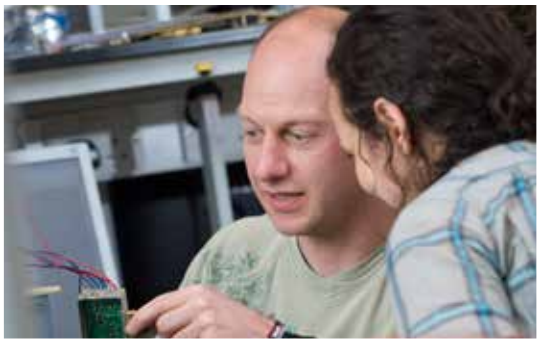
Themis Omirou has been working acoustic levitation and its application to 3D path visualizations. The work was presented at CHI 2015.

Tom Kealy has used his background in mathematics to develop a distributed algorithm reconstructing spectrum data from undersampled measurements, and is trying to extend the sampling framework to arbitary sparsifying transforms of the spectrum.

Michael Collett, in his second year of research, has used knowledge gained from his first degree in Physics and the first year of the CDT in Communications programme, to design and develop an optically tunable gold microstrip patch antenna on silicon substrate.

Alex Kartun-Giles has developed a technique for a GPS-free localisation technique for terminals in 5G networks using the theory of random graphs, inspiring work at Toshiba.

Tom Barratt's first year PhD research on millimetre wave channel characterisation has been supported by Blu Wireless Technologies who provided access to a bespoke beamforming 60GHz antenna array and industrial mentoring.



Skills Training

"The EPSRC ICT Pioneers competition involved presenting your research to the panel of judges, and helped build on my presentation skills and develop my ability to communicate complicated concepts to a non-specialist audience."

Leo Laughlin, Student

During the year CDT students were given the opportunity to participate in a wide variety of non technical broad skills training opportunities organised by the Centre to enhance their ability to promote the impact of research. These included 'Poster and Abstract Writing', 'Presentation Skills', 'Outreach for Schools', 'Writing your Thesis', 'Body Language & Vocal Skills for Presenters', 'Elevator Pitches', 'Writing Technical Papers 'and 'High Impact Research'.

Students were also able to participate in activities organised by the Faculty of Engineering, the Bristol Doctoral College and the LIbrary such as 'Managing your PhD', 'Communcating with your Supervisor', and 'Research Data Management'. These events also provided the CDT in Communications students with the opportunity to share experiences and knowledge with postgraduate students from other Centres for Doctoral Training at the University of Bristol.

National Instruments (NI) continued to support the activities of the CDT researchers as well as postgraduates in the host research groups. This year five postgraduates attended the NI Labview FPGA intensive training course in Budapest, joining delegates from TU Dresden. The new skills acquired facilitated the rapid use of the NI Vector Signal Transceivers (part of the CDT Equipment award) by Leo Laughlin and Chunqing Zhang and their work on Full Duplex wireless.

Moray Rumney and Tim Masson from Keysight Technologies have given several in-house seminars as well as training on their LTE Basestation emulator, known as a PXT. James Birchall has used the PXT on extended loan to the lab.

Many of our researchers have made use of the extensive training courses offered by Rohde & Schwartz through the Technical Academy as well as the EU COST summer and winter schools.

Tom Barratt attended the Radiowave School in Bologna, the home of Marconi.

Leo Laughlin was a finalist in the EPSRC ICT Pioneers competition.

Oliver Norman undertook a secondment to Toshiba's R&D Centre near Tokyo, creating a packet-level simulation of a wireless sensor network incorporating localisation protocol design. Novel time-variant findings were accepted into a Japanese workshop. Oliver extended his awareness of Japanese business culture, and brought home a renewed love of tinkering with technology!

The hosting research groups hold regular internal seminars, allowing CDT researchers to present their research to a technical audience as well as learn from others in their specialisation. This continually prepares and skills our students for presenting at external events.

"As a postgraduate at Bristol I have benefited from the additional training that the CDT attracts from industry to our lab, both on and off site."

Chunqing Zhang, MSc by Research student

Annual Student Research Conference & Public Lecture

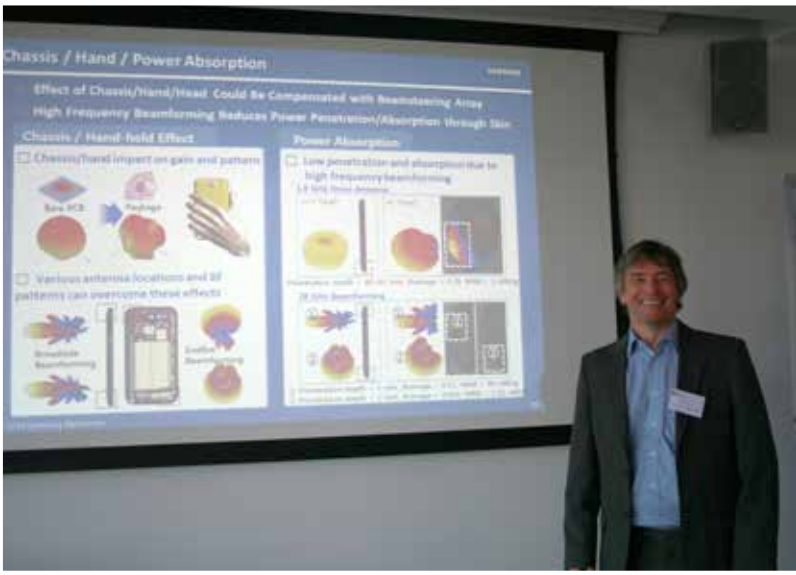
This year's public lecture was given by Dr Howard Benn, Head of Standards and Industrial Affairs at Samsung Electronics R&D Institute, UK. Industry, students and the public were enlightened by his lecture on the subject of 'Millimeter Wave as a Key New Element in 5G Cellular Networks' in which he discussed the latest developments in the field.

On the following day, Friday 25th September, the Annual Student Research Conference was held. As our CDT has grown in size, the scale and importance of the event has been expanded. Last year, we attracted an audience of over 80 participants from industry and academia. This year we hosted the event M Shed - home to Bristol's industrial heritage - and the students presented to an even larger audience that the previous year. We were delighted that the speaker from the previous night's lecture was able to join us and hear about the exciting research being undertaken by students. Enthusiastic presentations on a wide range of topics including 'Optically Reconfigurable Microwave Components for Communications', 'Ultra-Broadband Power Amplifier Linearization', 'Distributed Compressive Sensing for Wideband Spectrum Sensing', 'Visual Sense and Avoid for UAVs, Continuous Low Power Wearable Computing for Health Applications', 'Adaptive Broadcast Techniques for Digital Terrestrial Television', and 'Flexible Duplexing for 4G Cellular Handsets' were given.

First year students presented technical posters on the project they had undertaken over the summer months. Topics included: 'Future Efficient Amplification with Outphasing Networks (FAWN)', 'Wireless SDN Integration in Heterogeneous Networks & 5G', 'Biologically Inspired Vision Systems using Polarized Light', 'Investigating the Security of the Lower Layers of Wireless Technologies Powering the Internet of Things' and 'Distributed Interference Management in Dense Wireless Environments'.

Both the lecture and the conference provided an ideal opportunity for staff, students and industry to network in an informal environment and to discuss issues current in the industry as well as allowing for in-depth Q&As on the research being undertaken.

> *"The conference was an excellent mechanism for showcasing the breadth and depth of the CDT research projects."*
>
> *Moray Rumney, Keysight Technologies*



Outreach

"From inspiring potential engineers still many years away from starting their careers, to disseminating the benefits of research once it has been done - outreach is at the core of why we do research in the first place."

Chris Morris,
Chair, Student Outreach Commtittee

During the last year, postgraduate students and academic staff were involved in a number of initiatives to promote engineering to the public. The Outreach activities within the CDT were organised by a group of enthusiastic postgraduate students, with the support of staff.

A programme of outreach activities was established between the Centre and Colston's School, Bristol. As part of this programme, staff at the School provided postgraduate students with training on working with school children, and developing their interest in a subject. These skills were put into practice at a workshop held at the School on the 26th June. A group of year 10 and year 12 students visited the Centre on the 27th February to learn about career opportunities in Engineering, why the postgraduates found Engineering an exciting career path and enjoyed a tour of the communications research lab.

Postgraduates also participated a range of outreach activities organised by other groups. Themis Omirou and Paul Worgan worked with school children from a local school, Red Maids, to form the winning team in the Dress Sense technology competition. This was organised by the University of Bristol's SPHERE project (an EPSRC IRC) that challenged teams of medics, scientists, engineers, designers and textile artists to design a piece of wearable technology with a health benefit. The winning project, - 'Yo' - was a support system to aid cognitive behaviour therapy to break negative thought cycles and alter behaviour patterns, resulting in a positive change of mood included.

Divya Mohan has been working as a STEM ambassador with Fairfield School, and Paul Harris is a STEM ambassador for Redland Green School in Bristol. Paolo Enrico de Falco is working in the University as a Student Ambassador to promote widening participation.

The students developed hands-on exhibits for the annual Bath TAPS (Taps into Science) event held at the University of Bath on the 21st March 2014. The festival was attended by over 1,600 years 6-9 schoolchildren from both from the local area and from as far afield as London and Spain. They had the opportunity to learn about what fun engineering can be. The CDT activities encouraged them to learn about Communications technology with the opportunity to make cup phones, to learn about mobile phone network planning via an interactive game and to consider how technology has developed in phones to make them smaller, lighter and more energy efficient.

Success in Bid for Specialist Equipment

In order to deliver advanced training, our CDT must provide the best and most relevant research, validation and demonstration capabilities. In July 2014 we successfully bid to EPSRC for £400,000 of new equipment to support the delivery of its research and training programme. The new suite of advanced capture and evaluation equipment is being used for PhD research in 5G communications (and beyond), advanced software defined networks and immersive video transport. The equipment will underpin group projects as well as research phase work, enhancing our research students' training and employability and ensuring our credibility with key CDT industry partners.

The equipment purchased includes a NetFPGA processor farm that offers a flexible and open platform for networking, image processing and HPC; a Multiple Vector Signal Transceivers Platform for optimisation and validation of next generation waveforms, and advanced receiver algorithms; a Wide Band Waveform Generation and Digitisation System comprising a dynamically reconfigurable National Instruments 2GHz+ baseband platform for next generation wireless research; an Agilent Infinium High Performance Oscilloscope to address the increasing need for high speed wideband test equipment; and a suite of video acquisition and display equipment to support research in the effective transmission of immersive video formats, including an AMP HDR camera, a Tobii TX300 eyetracking system, a Sony professional 4k monitor and a Mikrom High Frame rate display.

"This equipment award will enable us to provide the best facilities for our students, including many unique items. It will ensure that Bristol's CDT remains at the cutting edge of research in this rapidly developing and important field."

Professor David Bull,
CDT in Communications Director

How to Get Involved

Industry

We welcome proposals for research project topics that can be sponsored - through fully funded studentships, iCASE, and Case conversion awards. from industry (exisiting and new collaborators).

We are also keen to further develop the specialist training available to our students and ensure the provision of state-of-the-art test & measurement equipment. If you wish to become a partner in the Centre please contact Professor Mark Beach, Centre Manager (M.A.Beach@bristol.ac.uk).

Prospective Students

Applications from potential students are accepted from October each year for entry in the following September. Please contact the Admissions Tutor, Dr Simon Armour, (Simon.Armour@bristol.ac.uk) if you would like to discuss opportunities for study.

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Our Supporters & Collaborators

Student Research Projects - 2013 Recruits

Student:	Imad Al-Samman
Project:	Wireless SDN Integration in Heterogeneous Networks & 5G

Imad graduated from Lancaster University with an MSci (Hons) degree in Mobile Broadband Comms.

In order to address the increasing demands for wireless, network operators have reduced cell sizes and cell densification is now common in areas of high demand. Today it is common for users to make significant use of WiFi connectivity alongside carrier grade services provided by the cellular operators. However, the interworking between these different bearer classes is far from seamless. There is a clear need for seamless interworking between the different wireless connectivity mechanisms, i.e. heterogeneous access, for 5G and beyond networks.

There is also considerable interest in the application Software Defined Network (SDN) methodologies from fixed networking paradigms with the separation of the control and data planes for the real time management of wireless networks. This potentially offers many advantages in terms of the dynamic re-purposing of network resources and also harnessing the power and reduced costs of Cloud based computing resources, now referred to as Cloud-RAN (Radio Access Network).

Given that the characteristics of a wireless bearer are significantly different to that of a fixed network with fibre access, this project will address if the wireless control embedded in the medium access control (MAC) can be hosted centrally in an SDN architectural deployment. Consideration will be given to signalling requirements (rate and latency) of processes governing the modulation and coding schemes, power control, handover etc of the wireless bearer. In order to circumvent a potential telecommunications bottleneck in the wireless SDN control plane and poor wireless quality of service, different architectures will be proposed and assessed as well as the seamless integration of multiple bearer types for future heterogeneous access.

Student:	James Birchall
Project:	Theoretical/practical analysis of UE uplink power distribution

James graduated in 2013 from the University of Sussex with an MEng (Hons) in Electrical & Electronic Engineering.

The statistical distribution of uplink power in a cellular network is a critical factor in determining for example how useful envelope tracking is in improving PA efficiency, and optimising module thermal management through reducing power dissipation. There is some very limited information available for smartphone applications but almost none that is relevant for LTE modems embedded in machines and for alternative application scenarios.

This project is analysing typical applications to determine their traffic profile, measurements on data networks to confirm the analysis, instrumenting LTE modems to determine transmit power as a function of network activity, measurement in drive tests or analogous deployments, and constructing activity simulations based on measured/predicted coverage and LTE network scheduling models. The objective is to generate flexible models to predict UE output power over a range of applications to help system designers optimise transmitter design, evaluate the effectiveness of techniques such as envelope tracking, and devise system and circuit design guidelines.

Student:	Paolo Enrico de Falco
Project:	Future Efficient Amplification with Outphasing Networks (FAWN)

Paolo graduated in 2013 from the University of Portsmouth with a BEng (Hons) degree in Electronic Engineering.

Many contemporary communications and transmission standards such as LTE and DVB feature large phase and amplitude excursions which often result in low amplifier efficiency. This has resulted in the need for linear and efficient amplification techniques.

A number of candidate techniques are available as linearisation architectures such as Envelope Tracking and Doherty which have received considerable attention in recent years. The Outphasing or Chireix amplifier which is a high efficiency RF power amplifier architecture is another technique. Amplifier modes of operation like E, F and J could also be used to increase the efficiency of a complete linear amplifier system.

This project investigates the ever increasing challenges facing amplifier designers as bandwidth and signal dynamic range continue to increase. It will investigate possible candidate linearisation and amplifier architectures to develop a suitable system for future broadband high dynamic range highly efficient amplification.

Student:	Paul Harris
Project:	Massive MIMO for High Capacity 5G Networks

Paul graduated in 2013 from the University of Portsmouth with a BEng (Hons) in Electronic Engineering.

By 2020, fifth generation networks will be expected to handle data traffic 1000x that experienced today. Modulation schemes are reaching their limits and purchasing additional spectrum, despite the limited availability and cost, will not be sufficient to achieve this alone. In a massive MIMO system, large antenna arrays exploit the spatial diversity of the radio channel to allow many terminals to use the same time-frequency resource, simultaneously increasing energy efficiency and reducing the requirements on the RF chains. However, despite the theoretical predictions, many challenges remain when it comes to implementing such a system. With recent advances in test-bed design there is great scope and opportunity for extensive real world experiments with early tests demonstrating sum-rate capacities of up to 85 bps/Hz.

This project aims to tackle massive MIMO research pragmatically in an attempt to bring the technology from the chalkboard to the radio mast. Research opportunities have been identified in antenna array configuration and distribution, the use of single-carrier transmission schemes in place of OFDM, and the mitigation of pilot contamination. A successful implementation of this technology could provide the dramatic jump in capacity required for 2020 by sidestepping the Shannon limit.

Student: Joe Hollinghurst

Project: SDN (Software Defined Network) Solutions for High-criticality Networks

Joe graduated from the University of Bath in 2013 with a BSc (Hons) in Mathematics.

Communication networks are facing new challenges. There is an increasing expectation that the network user can request a network service without having to understand how the network infrastructure behaves or can be configured. Furthermore, there is an expectation that the communication network infrastructure configuration can be changed on demand. Two current framework solutions that address these challenges are Software Defined Networks (SDN) and Network Function Virtualisation (NFV).

We propose to look at on-demand network infrastructure management solutions for single-owner multi-tenanted high-criticality networks, such as those found in critical networked systems (smart grids, air traffic management and aircraft connectivity, ships, industrial plants, or rail systems). The main characteristic of these networks is that, although they may use a mixture of communication technologies, the networking solutions are often dedicated and use highly specialised hardware platforms in order to ensure (quasi) deterministic end-to-end behaviour of the network services as seen by applications.

These networks are typically configured and used in a fixed/static manner and in most cases are separated from best-effort networks, thus increasing the cost and network management complexity. It is desirable for such network silos to be integrated over a common physical infrastructure, but such a substrate would need to be able to provide the performance characteristics of the original silos for the relevant traffic, in terms of end to end delay and jitter bounds, resilience, etc. The work will therefore consider an SDN controlled network infrastructure (e.g. a highly connected mesh of Ethernet switches providing high capacity and path diversity between endpoint) and investigate how the resources and offered load can be modelled in such a way as to derive traffic engineering solutions that deliver the performance requirements of each flow.

Student: George Margelis

Project: Investigating the security of the lower layers of wireless technologies powering the Internet of Things

After graduating from the Physics department of the Aristotle University of Thessaloniki, George obtained a MSc in microelectronics.

The vision of an Internet of Things (IoT) is coming closer to realization with each passing day, propelled by advancements in embedded systems, wireless communications, sensor design, automation and machine intelligence. It promises to dramatically improve our lives, by automating and optimizing hundreds of areas like item-tracking, monitoring and adjusting environmental parameters like temperature, or humidity, healthcare monitoring or even traffic monitoring and shaping

However, because of the wireless nature of the IoT, it is highly vulnerable to a number of attacks, including eavesdropping, de-authorization attacks, or denial of service attacks. It is also important to note that the vast majority of the devices that will form the IoT will have to rely on batteries for power, which in turn limits their computational capabilities, leading to less than ideal security implementations. Considering that in the future the IoT will have control of important aspects of critical infrastructure like power/water supply, surveillance, industrial control and even vehicle automation the security of the network is of paramount importance.

Objectives of this PhD project include a thorough study of the technologies that are competing to become the de facto standards for the IoT, and a deep examination of the security and vulnerabilities of the lower layers of a wireless network deeply integrated into national infrastructure. To achieve the above, modelling of 802.15.4 and similar networks will be a key aspect of this project, as will be the examination of possible weaknesses of the physical layer and strategies to mitigate them.

Student:	Oliver Norman
Project:	Tuneable, compact, efficient antennas for wireless communications from 300 MHz to 3 GHz

Oliver graduated from the University of Birmingham in 2011, with an MSci (Hons) in Physics. He subsequently spent two years working in industry as a graduate physicist on various RF technologies.

Optimal performance of a wireless communications system requires the antenna to be tuned to the desired frequency of operation. If the resonant frequency of an antenna does not match the required frequency, signal strength is degraded. Preserving sensitivity in the antenna can offer reduced operational cost as well as reduced energy consumption.

Interactions between an antenna and objects close to it can cause the antenna to become detuned. Alternatively, many modern communications devices require multiple frequency bands to be covered using a single radio system, requiring an antenna to demonstrate "frequency agility." The adjustment of resonant frequency is performed using similar techniques in either case, thus a source of frequency agility is a highly desirable way to boost performance.

Additionally, tuneable antenna loading can improve the efficiency of electrically small antennas. Such antennas present low transmission efficiency and difficulty in impedance matching over broad bandwidths, but are expected to enjoy continued popularity in mobile devices due to their low profile and space considerations in consumer devices. Tuning can offer an increase in efficiency via an extension of effective electrical length.

The relative benefits of different tuning technologies for prioritising agility, compactness and efficiency will be examined in this research project. Technologies of interest include digitally tuneable capacitors implemented in RF MEMS, and metamaterials based on high permittivity substrates such as barium strontium titanate. This project differs from the literature by pursuing techniques relevant to the lower UHF frequencies, in addition to the common 3G/4G frequencies.

Student:	Alex Tibbs
Project:	Biologically inspired vision systems using polarized light

Alex graduated from the University of Bristol in 2013 with an MSci (Hons) in Mathematics.

It is well established that many animals have the ability to perceive and use the polarization of light as a source of visual information. The extent of polarization sensitivity in animals greatly varies between species, and this visual adaptation is often task specific. Amongst animals, polarization sensitivity is used for navigation, object detection, contrast enhancement and communication.

Very little work has been done to exploit the polarization of light in engineered vision systems. Recently, polarization has been used to dehaze images, detect objects such as underwater mines, perform stress analysis and identifying material defects. It is still nonetheless, an underexploited tool. Polarization is especially useful for seeing objects that are either smooth and reflective or transparent. The challenge of using polarization is the added complexity associated with the extra degrees of freedom introduced, when both capturing and processing image data.

The aim of this project is to develop a computer vision system which takes polarization images, performs robust feature extraction, and classification, for applications such object detection. The performance of such systems will be benchmarked against existing modalities.

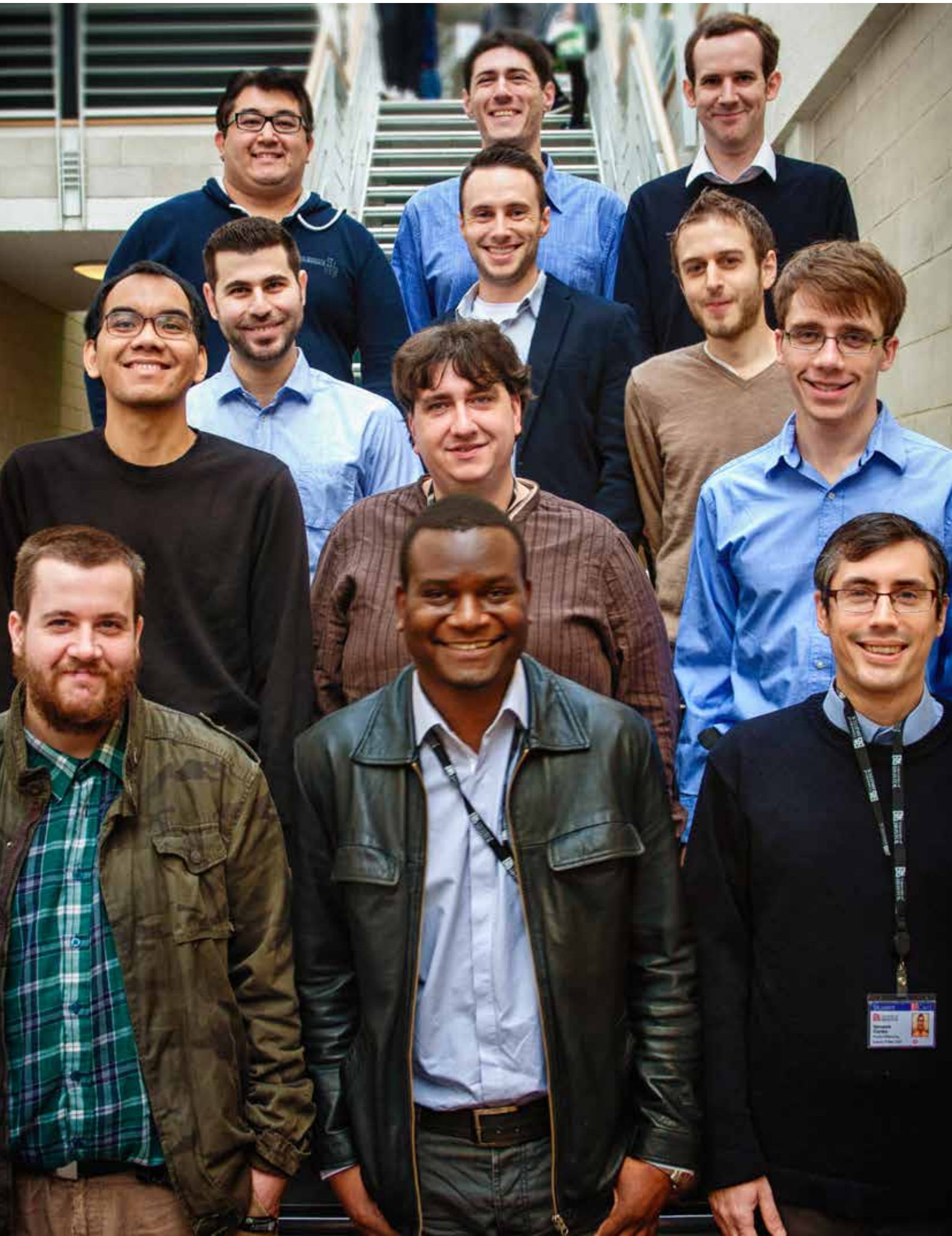
Student:	Chris Waters
Project:	Distributed Interference Management in Dense Wireless Environments

Chris graduated from The University of Strathclyde with a BEng (Hons) in Electronic and Electrical Engineering, and from Aston University with an MSc in Telecommunications Technology while working in industry.

As the density of wireless systems increases the scarcity of the radio spectrum resource becomes an even greater limiting factor than before; many wireless networks now are unable to provide adequate quality of service (QoS) to their subscribers. Not only is this a spectrum allocation problem but also many systems are limited by the interference caused to subscribers by their neighbours. These limitations are addressed through Interference Management, a key part of which is the technique of Interference Alignment, which has been emerging from purely theoretical works. In ideal conditions Interference Alignment promises a linear increase in potential channel capacity as the number of users in the network grows, potentially overcoming both the interference limit and spectrum allocation limits. However, Interference Alignment has many onerous requirements in order to be effective; perfect Channel State Information (CSI), precise time and frequency synchronisation, and the availability of sufficient degrees of freedom (DoF) to perform alignment (usually manifested in the number of transmit/receive antennas or cooperation between transmitters). In order for Interference Management to be practical other methods must be derived to meet these requirements.

Chris' research will consider methods for addressing the pragmatic implementation of Interference Alignment in a distributed wireless network with a large number of users.

Students - 2014 Recruits



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