Institution: Cardiff University

Unit of Assessment: 11

a. Overview

The School of Computer Science and Informatics structures and manages its research activity around three groups of roughly equal size that represent the School's core areas of research strength: Distributed and Scientific Computing (DSC), Informatics (INF), and Visual Computing (VIS). These research groups are a result of considerable restructuring and substantial investment in new staff, particularly ECRs. DSC's main foci include mobile computing, high-performance computing, and optimisation for problem-solving. INF's strengths are in distributed information management, decision-support, data mining, and geospatial informatics. VIS encompasses research in computer vision, computer graphics, and geometric computing. In addition the School leads the Human Factors Technology Research Centre, an interdisciplinary hub (in collaboration with the Schools of Engineering and Psychology and also the Schools of Dentistry and Optometry) to perform research into computational analysis of many forms of human interaction and perception. Each research group is led by a Head of Group with experience of directing major research programmes. The groups provide a supportive environment for the training of their postgraduate research students (PGRs) and the development of their Research Assistants (RAs). The School Research Committee sets research policy across the School, with cross-group representation comprising staff of various grades and PGRs, and takes advice from the School's External Advisory Board constituted from industry and public-sector advisors. In the latter stages of the REF period, under the leadership of new Vice-Chancellor Prof Colin Riordan, Cardiff University was re-structured into three colleges each led by a Pro Vice-Chancellor. Research carried out in UoA 11 is now within the College of Physical Sciences and Engineering.

b. Research strategy

Our **research vision** is to be ranked consistently among the top 150 Computer Science and Informatics institutions worldwide by 2018. We will deliver this through our five year strategic plan (2013-18) which is aligned with, and will benefit directly from Cardiff University's strategy for the delivery of excellence in research, innovation and impact. This is led by our new Vice-Chancellor and involves a £250M Innovation Fund for investment in staff, research students, and capital development. Our goal is to establish ourselves at the centre of research involving **data-enabled decision-making** across the University and beyond, in alignment with one of the research themes of the newly-formed College of Physical Sciences and Engineering. The principal elements of our strategy to achieve this goal are:

- **Implement further plans for larger research initiatives**. Use growing critical mass and emergent leadership within groups to build on our strengths and generate larger-scale research programmes. Share scientific challenges across group boundaries to develop new opportunities for internal and external collaboration and subject leadership.
- **Prioritise cross-discipline collaboration.** Seek further opportunities to generate knowledge and impact in other disciplines. Ensure prioritisation of collaboration that is based on new techniques, methods, and capabilities within Computer Science and Informatics. Align this with the institution's ambitions for University Research Institutes, tackling critical global issues that require cross-disciplinary co-operation.
- **Develop challenging research agendas through relationships with strategic partners.** Taking input from the School's External Advisory Board, identify strategic priorities and create new opportunities for academic, industry, and public-sector collaboration that sets agendas for future research challenges. Build on our existing network of strategic partners such as Tsinghua University China, IBM, the NHS, and the international biodiversity management community.

Achievement of the strategy will be supported by: increasing critical mass through investing in the best possible new academic appointments financed by expanding student numbers and the Cardiff University Innovation Fund; encouraging, rewarding and promoting subject leadership through a strong staffing strategy.

Current position with respect to RAE 2008: Over the period, research in Computer Science and Informatics has continued to thrive, with achievement of excellence in all areas, as evidenced by **significant improvement in key performance indicators**:

- doctoral degree awards have nearly doubled on average per annum, from 5.1 to 9.7;
- average research grant income per annum has risen by 41%, from £1.23M to £1.73M;
- research culture has further accelerated by 9 new academic appointments including appointment of 7 ECRs during the period;
- research groups were reorganised for improved critical mass and better alignment with major challenges in computing.

This performance has resulted from the School's objectives for the 5 years from RAE2008:

- exploit potential research synergies between members of the School;
- address major research challenges in computing and informatics;
- build on existing strengths in applied and interdisciplinary research;
- recruit high quality staff to strengthen existing groups and forge new directions;
- continue to enhance a vibrant research culture.

Following a Cardiff University-led review of the School in 2008, with external advice from a panel of academic and industry assessors, the School implemented a **new management structure** in 2009, including a new Head of School (Whitaker) and Director of Research (Preece). The School undertook a **major restructuring of its research groups**, then five in number with some having limited critical mass to support strategic and operational objectives. In a series of workshops, the School's research community, including RAs and PGRs, developed a set of **cross-cutting themes** aligned with major research challenges (pervasive, ambient and social computing; exploiting and interacting with distributed information; reasoning about and modelling the physical world). These themes were applied in two ways: (1) to inform the restructuring of the School into three groups, each with appropriate and well-balanced critical mass in terms of staff and PGRs, and (2) to encourage participation in more than one group, reflecting cross-cutting themes.

Following reorganisation, the School undertook a **recruitment programme leading to 9 appointments, with particular emphasis on early-career researchers** to re-balance the profile that had become skewed towards senior staff. Along with the group restructuring, this high proportion of newly-recruited researchers in the REF period has consolidated our strengths around **data-enabled decision-making.** ECRs appointed in period include: Lai (National Excellent Doctoral Dissertation of China Award, 2010; working in computer graphics, computer vision, and computer-aided design), Loukides (Royal Academy of Engineering Fellow specialising in privacy protection in data mining), and Schockaert (winner of 2008 ECCAI Artificial Intelligence Dissertation Award; working in uncertain reasoning and geographic information retrieval).

Building on these new structures and synergies, some of the **most notable achievements during the period 2008-2014** are:

- Generation of a **significant portfolio of projects in the areas of mobile and social computing**, involving members of the DSC and INF groups, including SocialNets (2008-2011, FP7, £345K), RECOGNITION (2010-2013, FP7, £494K), ITA (2008-2013, UK/US Govt, £533K); COSMOS (2011-2014, EPSRC/ESRC/JISC, £472K).
- Establishment of the **One Wales Research Institute of Visual Computing** (2009-2013, Welsh Government, £1.24M) with an aim to make Wales an internationally-leading country in areas including visualisation, geometric modelling, and volume graphics, with strong links to China's Tsinghua University (Tsinghua's Prof Hu also holds a part-time appointment at Cardiff).
- **Maintaining a diversified portfolio of research funding sources** through development of our interdisciplinary research with local, national, and international partners, for example our portfolios in healthcare (£2.1M from sources including EPSRC, NIHR, NISCHR, and Wellcome), biodiversity (£2.24M mainly from FP7), and security (£2.3M from EPSRC, EC, and industry).

c. People, including:

i. Staffing strategy and staff development

The School's research strategy relies upon the recruitment, development and retention of high-calibre research staff. We help ensure the vitality and sustainability of our research base by: (i) recruiting high calibre ECRs, (ii) developing ECRs into research leaders, and (iii) ensuring leadership of key research areas by senior staff. New appointments have been made in the interrelated areas of: privacy and data mining (3 ECR staff); geo-spatial informatics and text mining (2 ECR staff); visual computing (4 staff including 2 ECR). In addition to a total of 9 new

appointments, the development of early and mid-career staff includes five promotions with a further two pending.

The School is committed to **staff training and development in accordance with the Investors in People framework**. We gained full accreditation in 2011, Cardiff being the first Russell Group University to achieve this over the whole institution. A comprehensive range of development courses, including workshops on PGR supervision, leadership, project management and performance management, is provided by the University and used extensively by staff (over 140 course attendance registrations in period). The University's Research Leadership course won the 2010 Times Higher Education Award for Outstanding Contribution to Leadership Development.

Mentors are assigned to all new academic staff, whose integration is also supported by our group leaders. All staff benefit from internal appraisal procedures (which, for academic staff, is operated through the research groups) that review research progress against regularly updated objectives and identify specific needs. In the appraisal process, a **workload model is used to preserve equity and gain credit for all aspects of research related activity**, allowing the appraiser and appraisee to highlight areas of excellence and development on a fair basis. The model includes PGR and RA supervision, funded research projects, impact, explicit reward for excellence and minimum of three months per year for individual research where no specific demands are placed on use of the time. Additional time is provided for "citizenship" and School-level research activities (e.g. seminars and awaydays). Recovered indirect costs and overheads are returned to investigators through a transparent mechanism to incentivise income-generation activities (currently 25%) and reinvestment in areas such as strategic travel, equipment, and PGR support is encouraged. **Bid preparation is supported by an Internal Peer Review mechanism**, which provides proposers with early feedback on proposals under development. Reviewers are selected on the basis of experience and track records of success from relevant funding schemes, and are asked to comment in the same way as external reviewers. The School Research Committee supports staff in considering ethical aspects of research involving human subjects.

Cardiff University provides **comprehensive and integrated support to help early career researchers** (ECRs), including new lecturers and research associates, to develop transferable and career-development skills (shortlisted for the 2010 Times Higher Education Award, *Outstanding Support for Early Career Researchers*). In addition, the School has an ECR development scheme, utilising senior staff mentors, the College of Physical Sciences and Engineering operates an ECR Network, and ECRs are expected to make full use of the University's staff development programme (www.cardiff.ac.uk/humrs/training/programme/) as well as attending national and international conferences in their areas. ECRs are given strategic priority in assigning the School's internal studentships (providing up to three new PhD studentships per year). The School provides them with start-up funding support (currently at least £5K) and lower teaching loads for the probationary period. They are encouraged to apply to appropriate ECR schemes (including EPSRC, ERC, and RAE fellowships) and supported in doing so by the School's internal peer review mechanism, access to networks of previously-successful applicants, "mock" interviews, and support from the University's Research Innovation and Enterprise Services (RIES). During the period, for example, Loukides was awarded a 5-year RAE Fellowship. School ECRs are also selected to participate in **leadership and development programmes** such as the recent Cardiff Futures initiative (www.cardiff.ac.uk/humrs/staffinfo/leadership/cardifffutures/) and the Welsh Crucible scheme for building interdisciplinary networks (www.welshcrucible.org.uk).

The School has a specific **code of practice to implement the Concordat for the Career Development of Researchers**, developed by the School Research Committee and specifically managed by the Deputy Director of Research who continues to monitor compliance. In terms of research-related activities, research staff are considered equal to other academic members of the School: they are included on the main mailing list for School information, and are invited to participate in School meetings and research and impact-related briefings, both formal and informal. There is opportunity for them to serve in administrative roles and on School committees. All research staff are appraised annually using the same processes as academic staff, and opportunities for career advancement are considered as part of this process. The operation of the appraisal process is overseen by the Head of School and completion rates are consistently maintained at near 100%. All RAs are affiliated with a primary research group and are encouraged to participate actively in their group meetings, present their work, interact with PhD students,

discuss funding opportunities and, in several cases, set up collaborative networks with peers.

The School's Equality and Diversity Officer has responsibility to ensure that all staff are recognised equally within the School. All staff undertake mandatory training in E&D whilst initiatives and activities to support E&D are actively supported, such as College level networks for female researchers and ECRs. Flexible working is encouraged in the School, being arranged through line-management. The School also financially supports flexible working (e.g., home broadband and mobile communication costs). Consideration is given to the timing of events to ensure that staff with caring responsibilities are able to participate. Research-active staff also consolidate teaching duties where possible into one semester to allow fuller concentration on research in the other semester; many staff have a preference for this and regularly do so. Cardiff University holds an Athena SWAN Bronze Award. Cardiff University consistently ranks on Stonewall's *Top 100 Employers*, demonstrating our commitment to LGBT Equality (one of six Universities to appear on the 2013 list), and funds development activities for LGBT staff members.

Staff are encouraged to invite external academics to visit for periods of collaboration. **Since 2008 the School has hosted around 50 international visitors** (typically one week to 2-months) from places such as Tsinghua University (China), Calgary University (Canada), National University of Defence Technology (China), University of New South Wales (Australia), and University of Modena (Italy). The School maintains hot-desking facilities to accommodate such visitors, and also collaborators from partner disciplines (e.g. the Medical School). During the period School staff, including ECRs, have made extended visits to international institutions including Rutgers University, USA; University of New South Wales and University of Technology, Sydney; Victoria University of Wellington, New Zealand; IBM Research, Zurich and Dublin. The School's growing **international ethos** is also evident in its staffing: since 2008, all new appointments have been to individuals originating from outside the UK, including Belgium, China, Greece, Russia, and Serbia.

ii. Research students

The recruitment, management and supervision of high quality research students are important elements of the research life of the School. The School's strategy to PGR recruitment is to attract high-quality students with the potential to be excellent researchers or practitioners. The School has a **focussed approach to PGR recruitment**, encouraging all prospective supervisors to promote sample research topics on the School website, assigning the PGR admissions team in better fitting of applicants to prospective supervisors. These sample topics also serve as a "shop window" on our PGR research activities. The School operates a **rigorous progress monitoring mechanism**, involving detailed 6-monthly progress reports and an annual review in which a panel consisting of one "internal" (from the student's home research group) and one "external" (from another group) staff member advise on research progress and subsequent progression. In this period, to **encourage students to generate research outputs based on the work towards their thesis**, the annual monitoring mechanism was modified to allow them to submit a substantial research paper in lieu of a written report. This new mechanism was introduced in agreement with the students themselves, through the School's PGR-staff panel. Completion times and rates are closely monitored by the PGR Director, and key performance indicator data is fed back to Heads of Groups. Recently all major progress milestones were brought forward 6 months to encourage School PGRs to accelerate their progress and achieve earlier completions.

School funds are available to enable all PGR students to attend conferences during their studies, providing resources for one UK/European and one international. Twice-yearly, PGRs present their work and receive feedback from staff and students at the annual Poster Day and annual Research Away Day. **Effective interaction between postgraduates and staff in the School is promoted through regular seminars and social events**. External speakers participate in the School Research Seminar Series, which raises awareness of key research developments and helps to encourage interdisciplinarity. There are also internal and group seminars, normally at least two per week, where staff and students present their work or discuss specific research topics. **School accommodation is configured so that students and staff share common room facilities**. The School provides support and funding for them to operate their own seminar series (www.cs.cf.ac.uk/fts), and supports interdisciplinary events such as a Computer Science / Social Science Hackathon and establishing a Human Face Animation and Perception Network with Psychology. Many of our PGRs are interdisciplinary, notably with the Schools of Medicine,

Biosciences, Dentistry, Chemistry, Engineering, Pharmacy and Psychology. The recently-awarded **EPSRC Centre for Doctoral Training in Water Informatics Science and Engineering (WISE)** with the School of Engineering will significantly expand interdisciplinary activity in data analytics.

The School operates an **annual Monitoring of Postgraduate Research Activity, conducted against the University's Code of Practice**, covering areas such as the research degree portfolio, admissions procedures, quality and standards, and the PGR student experience. This informs an action plan implemented by the PGR management team in consultation with students, including consideration of actions arising from PRES feedback (for which the most recent results place the School 2nd in the College on overall experience, and 1st on quality of supervision). The **PGR Student Panel** is student-chaired and includes representatives from each group and year. It enables students to become more involved in the research environment and develop new initiatives, as well as providing a mechanism to respond effectively to any problems.

There is an **extensive training programme for postgraduate students**. The **University Graduate College** was short-listed for the 2010 Times Higher Education Award for *Outstanding Support for Early Career Researchers*, hosting over 200 training courses, conferences, careers events, speaker events, and online research skills modules. It ensures that all University PGRs complete ~10 School plus College training days per annum in core research skills, and that graduate students from the School are part of the wider University research community. The School's **international ethos** is prevalent in our PGR student body, with over half of our research students originating from outside the EU.

d. Income, infrastructure and facilities

Our research groups have been sustained over the period by **broad-based funding, including RCUK, EU, industry, and charity income**. Notable among these are:

- RCUK Global Uncertainties Consortium for Exploratory Research in Security (CEReS) "Understanding Human and Technical Factors to Combat Cybercrime" (£1.27M awarded by EPSRC/ESRC to DSC/INF groups in collaboration with the School of Social Sciences).
- Development of workflow-based tools by the DSC/INF groups for problem-solving in domains including physics and healthcare (including £1.1M from Wellcome Trust and £540K from EU).
- Our portfolio of linked biodiversity projects including Biovel (Biodiversity Virtual e-Laboratory), i4Life (Indexing for Life), and the LifeWatch and ENVRI research infrastructures (£2.24M awarded to INF group in the period from a variety of EU programmes).
- Sustained support for visual computing through the VIS group's key role in the One Wales Research Institute of Visual Computing (£1.24M from Welsh Government), EPSRC (£900K), and the Marie Curie Initial Training Network INSIST: Integrating Numerical Simulation and Geometric Design Technology.

To avoid overdependence on a small number of income sources in an unpredictable economic period, the School **encouraged and supported investigators to exploit a diversity of funding sources**. Over the period, funding by source is divided mainly between RCUK (23%), EU (32%), UK charities (13%), UK govt (21%), and UK industry (8%). In 2011-12, the most recent period for which we have comparative data, the School had the most balanced portfolio of funding across the five major categories (RCUK, EU, UK charities, govt & industry) in the upper quartile of the UK computer science and informatics sector. The School regards its funding strategy as having been successful in creating a **stable but steadily increasing base of funding** over the period (varying by less than 10% year-by-year and with the REF period average annual income 41% higher than the RAE 2008 annual average). Our strategy involves continuing with this approach, using group, School, and College-level structures to share experience and promote "success stories".

The revitalised research groupings and strong interdisciplinary and international links are central to our vision for continued growth, particularly through securing larger scale projects. Examples of recent successes of this kind include the aforementioned CEReS consortium involving members of the DSC and INF groups with social scientists, and also:

- Five awards for collaborative work between the School (DSC and INF groups) and Social Sciences focussed on social media scanning to inform policy-making on crime management (COSMOS and TaRDiS projects: £670K from EPSRC, ESRC, JISC, and the EC, 2011-2015).
- The School becoming a partner in the 10-year joint US/UK International Technology Alliance in Network and Information Sciences (NIS ITA, funded by the UK and US Governments, £533K to

Cardiff to date), involving collaboration with IBM UK/US, Pennsylvania State University, UCLA, the US Army Research Laboratory, and Dstl.
- The RECOGNITION project (Relevance and Cognition for Self-Awareness in a Content-Centric Internet) funded through the FP7 Future and Emerging Technologies Programme (£494K, 2010-2013) involving members of the DSC and INF groups, in collaboration with Cambridge University and partners in Greece, France, and Italy.

The School continues to benefit from the **considerable expansion in accommodation** achieved during the previous period, most notably the £3m West Extension building. This houses the School's sizeable biodiversity informatics team, our security and cyber-forensics lab, the Access Grid, modular seminar and meeting rooms, and accommodation for staff and researchers.

In terms of facilities, staff in the School have **direct access and support from the Advanced Research Computing facility** (ARCCA) at Cardiff University, which provides HPC capacity with a cluster of 2048 Intel Xeon 2.6 GHz cores each with 4Gb memory per core, as well as small, higher throughput clusters. This delivers capability and capacity for data analysis, large scale simulations, storage and visualisation, and is one of the largest and efficient academic supercomputer facilities in the UK.

The **Human Factors Technology Research Centre** is an interdisciplinary hub led by the School (in collaboration with the Schools of Engineering and Psychology and also the Schools of Dentistry and Optometry) houses a variety of motion capture systems used in full-body human-motion analysis research, a multi-camera video capture system currently used in research into assisting creative engineering design, and a state-of the art 3D video (including audio) system currently used in many facial analysis projects. Research has focused on innovative 3D facial dynamics studies that include the use of 3D face movement as a biometric, a joint study with the School of Dentistry on visual speech patterns as a tool in analysing patient surgical planning and monitoring recovery, dynamic facial models (include MRI muscle segmentation) as well as a collaboration with the University of Seoul and Technical University Cottbus, Germany, on pioneering work modelling and analysing (in 2D and 3D) conversational expressions and interactions between two people.

Four staff provide software and hardware support for all research projects. A School Manager, a Research Administrator and a Finance Officer provide administrative support inside the School. The School draws upon the support of the University's **Research, Innovation & Enterprise Services** (RIES) which provides extensive support in preparing, costing and submitting bids, and **FUSION IP, a company that signed an exclusive 10 year agreement with Cardiff University in 2007** to commercialise the University's IP. FUSION IP has supported the growth of the Medaphor spin-out during the period (specialising in the development and sale of advanced virtual ultrasound training systems, www.medaphor.com), and is currently working with School members on the spin-out of the DSC group's scientific workflow research (viavm.com).

e. Collaboration or contribution to the discipline or research base

The School has a **long-established (15+ years) culture of strategic collaboration with partner disciplines, at Cardiff as well as nationally and internationally**. In particular, we have built strong collaborations with disciplines where there is limited academic similarity, but the collaboration leads to new capability, innovation or impact in both computer science and informatics, and the partner discipline. **Over the REF period our staff have engaged in collaborations with nearly 100 UK and international academic partners** including Cambridge, Edinburgh, Manchester, Oxford, Southampton, UCL, Carnegie Mellon University, Pennsylvania State University, Vanderbilt University, Tsinghua University China, National University of Defence Technology China, University of Amsterdam, UPC Barcelona, and EPFL Switzerland. **Over 30 active collaborations are currently underway with industry and other organisations** including BT, EADS, IBM UK/US/Europe, the Ordnance Survey, Renishaw, the Royal Mint, Argonne and Oak Ridge National Laboratories USA, and Yahoo! Research Barcelona. Currently **the School has active collaborations with academic Schools** including the Business, Dentistry, Engineering, Medicine and Healthcare Studies, Mathematics, Psychology, and Social Sciences. The recently-awarded **EPSRC Centre for Doctoral Training in Water Informatics Science and Engineering (WISE)** is in collaboration with Exeter, Bath, and Bristol Universities.

All of our current major research activities and strengths have been heavily informed and

shaped by our collaborations. In recent years a major focus of the DSC and INF groups has been on improved distributed computing platforms for data management and problem-solving, motivated in large part by our collaborations with physicists, environmental scientists, biologists and medical researchers. A related thrust of work in these groups has addressed modelling and solving challenging optimisation problems, motivated by application in fields including telecommunications network planning, sensor networks, and green logistics. Data and text mining – with strong considerations of data privacy – has been a key priority of the INF group's work over the period, largely driven by collaborations with the Medical School and a number of industry partners detailed in REF3a. A particular priority of the research agenda in Visual Computing as pursued by the VIS group is the reverse engineering of CAD models - regenerating CAD models from scan data driven by increased availability of 3D scanning technology and collaboration with academia (especially Tsinghua University in China and the Hungarian Academy of Sciences). To foster knowledge exploitation and engagement from this work, the School appointed a technology transition officer to create links between the VIS group's research and beneficiaries, especially industry and SMEs. The group's strategic partners include CADScan, Delcam, Royal Mint, Renishaw, Transcendata, Simpleware, and nVidia.

The School is a **partner in several large-scale international research consortia** including the joint US/UK International Technology Alliance in Network and Information Sciences (www.usukita.org) established in 2007 as a 10-year programme between nearly 30 US and UK universities and companies. The programme, which was mentioned in a White House press release in March 2012 as a leading exemplar of US/UK research collaboration, is led by IBM; Preece became one of the two academic programme leaders in 2011. In the period 2007-2011, Rana co-led research themes on "Distributed Programming Abstractions" and "Distributed, Dynamic, Data Intensive Programming Abstractions" to better identify requirements for next-generation "big-data" infrastructure, jointly funded by the National Science Foundation (US) and National eScience Institute (UK).

The School is active in **government industry-academia programmes**. Notably, in the current period, members of the DSC group worked with the Welsh Government Economic Renewal Programme on a Digital Wales Research Hub project with BT to develop a generic, reusable methodology to evaluate the social, economic and cultural impacts of next generation broadband (NGB) deployment in rural areas of Wales. The results of this work provided a pre-NGB picture of value to policy-makers.

In terms of **professional leadership activities**, the School staff collectively hold wide-ranging editorships and editorial board memberships, including editorships of *Computer Physics Communications* (Elsevier) and *Concurrency and Computation Practice and Experience* (Wiley), editorial board membership of *ACM Transactions on Autonomous and Adaptive Systems*, *Journal of Cloud Computing*, *Computer Aided Design*, *Computer Physics Communication*, *Fuzzy Sets and Systems*, *GeoInformatica*, *Journal of Health Informatics*, and *Proceedings of the Royal Society A*. In addition, School members hold senior memberships of ACM, IEEE, and the BCS; 3 have served as members of the EPSRC Peer Review College during the period; 4 are Fellows of the Learned Society of Wales; one holds a Research Fellowship from the Royal Academy of Engineering.

Members of the School have given **keynote addresses** at widespread events including *International Conference on Knowledge-Based & Intelligent Information & Engineering Systems*, *IEEE/ACM Int. Conf. on Service-Oriented Computing*, and the *EPSRC Large Scale Complex IT Systems (LSCIT) workshop* and have organised or co-organised 17 conferences or workshops in the period, including *Computational Visual Media 2012 Beijing*, *IEEE CCGrid 2010*, *IEEE/ACM Int. Conf. on Autonomic Computing*, and *11th IEEE/ACM Symposium on Cluster, Grid & Cloud Computing*, and the UK e-Science All Hands Meeting 2010.

School members have performed in **advisory roles** for bodies including the US Department of Energy (on their Computer Science research programme), Hong Kong University (on their national research assessment submission), Horizon 2020 (on quantum technologies), and the International Collaboratory for Emerging Technologies (CoLab, 2007-2011). In addition, Taylor is a Consultant for the US Naval Research Lab, CTO for two start-ups in the US (SkyDesks.com and autopiptrader.com) and CIO of EIWCorp.com, while Rana is an advisor to CBNine, a company specialising in cloud computing for architecture and construction sectors.