Institution: Birkbeck, University of London

Unit of Assessment: 11 – Computer Science and Informatics

a. Overview

The **Department of Computer Science and Information Systems** is one of the four constituent departments of Birkbeck's **School of Business, Economics and Informatics (BEI)**. The Department celebrated in 2007 the 50th anniversary of its foundation as the Department of Numerical Automation, making it one of the oldest computing departments in the world. It has an established research reputation since the 1970s in applied artificial intelligence and information management, and these have continued to develop as strategic priorities up to the present day.

The Department currently has 21 academic staff: 7 Professors, 1 Reader, 3 Senior Lecturers and 10 Lecturers, eighteen of whom are being returned in this REF. A further two senior academic staff are on leave of absence until 2014. Also returned as part of this UoA is the Executive Dean of the School of BEI, Professor Philip Powell, who is past President of the UK Academy for Information Systems (IS) and affiliate member of the IMWT group.

There are currently two main research groups, of roughly equal size: **Computational Intelligence (CI)** and **Information Management & Web Technologies (IMWT)**. These groups have a mentoring and peer support role rather than a formal management function. The boundaries between the groups are fluid, allowing subgroups to emerge within and between them, facilitating departmental cohesion and links with other departments and institutions. For example, staff from both groups have been engaged in substantial research since the 1990s in bioinformatics and health informatics, are affiliated with Birkbeck's new Centre for Cognition, Computation and Modelling, and are engaged in collaborative research with the Institute of Education (IoE) at the **London Knowledge Lab (LKL).** The Department established the LKL in collaboration with the IoE in 2004 with the aim of undertaking interdisciplinary research into the relationships between knowledge, learning and digital technologies. Currently four academic staff members of the CI and IMWT groups constitute the **Learning Technologies subgroup.**

Birkbeck's five Schools were created as part of the College's restructuring in 2009. The creation of the School of BEI in 2009 led to the establishment of the School's Research Committee, which has played an important role in enhancing support for research staff, increasing funding for research studentships and for research pump-priming, introducing more detailed processes for ethical review of research, and spreading best practice among the School's departments. All Schools have separate Research and Teaching committees, both reporting to the School's Executive Board. There is a College Research Committee (CRC) which reports to the Academic Board, and likewise a College Teaching and Quality Enhancement committee. The Research Students Sub-Committee of the CRC has responsibility for all matters relating to research students and postgraduate research. Thus, a balance is maintained between the requirements of the College's research and teaching missions, and the interests of staff and students as researchers are represented throughout the organisation.

b. Research strategy

Since the 2008 RAE, the Department's research strategy has been to maintain and strengthen further its position as an international centre of research expertise in CI and IMWT. Within these, we identified as strategic development priorities several areas in which we were already very strong: algorithms, applied machine learning, data mining, learning technologies, pervasive computing and semantic web. Our strategy has four key elements: (i) strategic recruitment of staff whose research enhances and extends our CI and IMWT specialisms; (ii) providing a vibrant research environment in which staff and research students have the support, guidance and training they need to achieve their maximum potential; (iii) actively pursuing collaborative research that exploits our expertise in CI and IMWT – nationally, internationally and across disciplines; and (iv) working on significant research problems whose solution results in tangible benefits to peoples' personal, cultural and working lives. The effectiveness of our research strategy is evidenced by the research advances made by our research groups since 2008:

Since the 2008 RAE, the CI group has addressed challenges arising from the **computational interpretation of complex data**, producing outputs published in leading fora such as JACM, AI, IEEE PAMI, STOC. Group members have worked on computational properties of logics, algorithm design and complexity, image understanding and classification, data mining, supporting users' access to complex data sources via ontologies, and adaptive systems. This research has led to new statistical methods for image understanding and classification (Maybank); solution of key open problems in vector addition, algorithmic game theory, algorithm complexity and parametrised

algorithms (Lachish, Razgon); advancements in the understanding of the graph reconstruction problem (Fenner), the axiomatisability of equational theories (Mikulas) and the computational properties of spatial logics (Kontchakov, Zakharyaschev); development of novel data mining algorithms for fraud and anomaly detection (Weston); new methods for neural network training inspired by human learning (Magoulas); and novel ways to utilise Graphics Processor Units (Magoulas). Collaborative research by Maybank with Northwestern Polytechnical University, Xi'an, and the National Laboratory of Pattern Recognition, Beijing, has investigated object detection and tracking in multiple image sensor environments, producing algorithms being used by several electronics and telecoms companies (e.g. Hanvon Technology, Beijing Theta Networks Technology, SURFILTER Networks Technology). In work undertaken as part of the EPSRC ExODA project, Kontchakov and Zakharyaschev identified description logics that are suitable for ontology-based data access (OBDA), contributing to the W3C OWL2 standard. In collaboration with Free University Bolzano, they implemented a highly optimised query rewriting engine incorporated into the ontop OBDA system (ontop.inf.unibz.it/) which is the core of the Optique platform being developed in an EU FP7 project at Oxford with Siemens and Statoil.

Since the 2008 RAE, the IMWT group has addressed challenges arising from the **ubiquity of information in virtual and physical spaces**, producing outputs published in leading fora such as ACM TODS, TCS, VLDB, SIGIR. Group members have worked on the management, querying and analysis of heterogeneous data, mining and retrieval of information from digital resources, understanding the needs of users through their interactions with mobile and pervasive systems, and understanding the factors affecting the IS strategies of organisations. This research has led to new algorithms, languages and complexity results for ontology-based data access (Cali) and for querying graph-structured data (Poulovassilis, Wood); novel algorithms for sequence searching and mining (Papapetrou), information retrieval and text mining (Zhang), and aggregating recommendations based on user-specified preferences (Wood); new methods for comparing rankings and their application in search engines and bibliometrics (Levene); novel architectural approaches for the Internet of Things (Roussos); and new insights into factors influencing the contradictory outcomes of organisations' experience with implementing IS (Powell). An EPSRC Ubicomp Challenge project investigated the motivations and spatial behaviour of museum visitors; work on pattern matching and detection in extremely resource-constrained wireless sensor networks received the 2009 WiSiG Best R&D Demonstrator Award of the Sensors and Instrumentation KTN; and work on citizen science in the Indicator Bats project was a Medallist for Environmental Project of the Year at the 2011 BCS UK IT Industry Awards (Roussos). An AHRC project with Birkbeck's School of Arts developed an ontology integrating information about Andean textiles and related cultural knowledge (Helmer, Poulovassilis). A new research collaboration with the Taylor-Schechter Genizah Research Unit at Cambridge is using our Samtla text search and mining tool to interrogate their collection of medieval Hebrew and Arabic manuscripts (Levene, Zhang). Our most recent appointment, Han, investigated the counterexample generation problem in probabilistic model checking and solved a long-standing open problem of model checking finite continuous Markov chains with respect to a linear real-time specification.

In Learning Technologies, research has focussed on **adaptation and personalisation technologies to support learners and teachers** (Gutierrez-Santos, Magoulas, Poulovassilis) and **mobile and pervasive learning environments** (Roussos), producing outputs published in leading fora such as Computers & Education and IEEE TLT. A key part of this work has been the development of new interdisciplinary methodologies for conducting learning technologies research. The MiGen and LDSE projects funded by the ESRC/EPSRC TEL programme developed intelligent constructionist tools for learning algebra and for supporting teachers in learning design. Research funded by the EPSRC DeTaLe and JISC GeoScieTeach projects developed tabletop and mobile interfaces for technology enhanced learning and was selected for an Intel Research WISP award in 2009. New collaborations have been forged with European partners in personalised learning and recommender systems. For example, the iTalk2Learn project is extending intelligent tutoring systems with new interaction modalities, and the LIBE project will research and develop personalised technologies for supporting literacy, numeracy and problem solving.

For the next five years, the Department will build on these achievements by continuing to pursue its dual strategy of investigating fundamental research problems whose solution will advance knowledge in the discipline, and undertaking collaborative research with partners from other disciplines that exploits and enhances our expertise. We anticipate that significant research

advances will continue to be made in algorithms, computer vision, data access, data mining, information retrieval, information systems, learning technologies, logics, machine learning, pervasive computing and semantic web. In all our research activities we will continue to strive for innovation and rigour. Our overarching strategic aim is to exploit the research expertise and research advances being achieved by our CI and IMWT groups in order to make contributions that have a lasting impact on theory, practice and society.

c. People

i. **Staffing strategy and staff development**

As stated in our RAE 2008 submission, our staffing strategy is to recruit staff of the highest calibre whose research complements and enhances our core strengths in CI and IMWT as well as our collaborative research activities. The retirement of several academic staff has enabled eight new lecturer appointments to be made since 2008 (all ECR) who are demonstrably meeting this aim – as evidenced by the research expertise they are contributing to the Department, the quality of their publications, and their extensive research collaborations. The overall number of academic staff has been maintained as has an even balance between senior and junior grades. The new appointments are: Cali (knowledge representation and management, semantic information integration, deep web querying; Postdoc at Oxford, PhD from University of Rome "La Sapienza"), Gutierrez-Santos (learning technologies; Postdoc at Birkbeck, PhD from University Carlos III, Madrid), Han (software specification and verification; Postdoc at Oxford, PhD from Aachen), Kontchakov (knowledge representation and reasoning, description logic, ontology-based data access; Postdoc at Birkbeck, PhD from King's College London), Lachish (algorithms, algorithmic game theory, complexity; Postdoc at Warwick, PhD from Haifa), Papapetrou (searching, mining and indexing large data; Postdoc at Aalto University, PhD from Boston), Razgon (fixed-parameter algorithms, graph theory, constraint satisfaction problems; lecturer at Leicester, PhD from Beer Sheva) and Weston (statistical analysis and data mining; Postdoc at Imperial, PhD from Imperial).

The Department's research collaborations involve frequent staff visits. For example, visiting staff have come to the Department during this REF period from universities in Chile, Cyprus, Italy, Spain and China; and members of the Department have held Visiting Professorships at the universities of Bolzano, British Columbia, Chile, Concepcion, Groningen, Innsbruck and Institute of Automation Beijing. The Department provides generous financial support to academic and research staff to present papers at conferences and to undertake research-related visits.

All academic and research staff are assigned to one of the research groups as their primary affiliation, providing peer support alongside mentoring by senior staff. Each new member of academic and research staff is assigned a research Mentor from within their group who provides guidance in the development of their research, including advice on research training, applying for research funding, research student supervision, and forging collaborations with other institutions and disciplines; this is in addition to their Probationary Advisor who appraises annually all aspects of their work. All staff continue to have access to a research Mentor throughout their employment.

All staff are offered an annual Professional Development Review (PDR) with a senior colleague of their choice to consider their career aspirations, the balance of their work, and any inhibitions to progress in research, teaching and administration, and they are strongly encouraged by the Head of Department to take advantage of this. Performance in research, teaching and administration are all recognised by the promotion and remuneration processes of the College.

The College's Learning and Organisational Development team coordinates training in staff recruitment, research supervision, research project management, line management and applying for research funding. All staff are required to keep appraised of the College's procedures for Ethical Review of research involving human participants, and the Department's Research Ethics Officer reports annually to the School's Ethics Committee on ethical reviews of all such research undertaken in the Department. The School's Business Engagement and Impact Group organises events relating to exploitation of research. The School has an Entrepreneur-in-Residence who heads the Entrepreneurial Innovation programme, including an Entrepreneurial Coaching Programme for staff and students and a student-led Enterprise Hub organising workshops and seminars (Roussos is on its steering committee).

The Department's Research Committee serves as a forum for formulating research and impact strategies, research planning and support, and setting and monitoring the achievement of objectives for enhancing research. Its core membership comprises representatives of the main research groups, the research staff, and the research students; all academic and research staff are

encouraged to participate in its meetings. The Department's Research Committee reports to the School Research Committee on research planning and strategy, support for researchers, and research student recruitment, funding, training and progression. The School Research Committee in turn reports to the College Research Committee. (Poulovassilis has chaired the School Research Committee since its inception, in her role as Assistant Dean for Research.)

Weekly departmental research seminars, delivered by internal and external speakers, enable new staff and research students to become quickly integrated. Staff and research students have numerous fora for intellectual exchange: the departmental research seminars; annual Research Days of the Department; research seminar series at the LKL, the London Logic Forum (which two members of the CI group, Zakharyaschev and Mikulas, co-founded), LogIC at Imperial, the Mobile Systems and Media Futures seminars at UCL; and several other London University seminar series.

The Department has a transparent model for allocating teaching and supervision duties to academic staff. Administrative duties are rotated every few years and staff are encouraged to discuss their preferences with the HoD. The College permits academic staff to take one term in every ten as sabbatical. In practice, one or two staff in the Department take advantage of such leave each year and are required to report back on how they have used this leave and the research outputs and other outcomes achieved. The administrative and teaching duties of new academic staff are kept below the departmental average in order to foster the development of their research at this critical early stage; this period lasts at least three years for early career staff. Mentors and other senior staff provide guidance on drafting first grant proposals. A formal internal peer review process operates for all grant proposals that are to be submitted for external funding.

The School operates a Research Fund whose aim is to pump-prime the research of new staff and new research collaborations. Applications are made annually and are reviewed by a cross-School panel. Department staff have been awarded about £50K of such grants since 2008. The School also has a budget to support staff in developing impact from their research. Applications to this are made twice a year and are reviewed by a sub-panel of the School's Executive Board. Department staff have been awarded funding for seven such projects. The School awards an amount of funding each year to holders of external research grants to assist in research costs.

Measures in support of equality and diversity include: a positive review of promotions undertaken annually to identify staff whom the HoD then encourages to apply for promotion; support during the promotions process through meetings with the HoD and the Dean of School for advice on how to maximise likelihood of success; proactive encouragement of appropriately qualified internal candidates by their mentors to apply when staff vacancies arise; support for flexible working, with core working hours 10am-4pm, evening teaching not exceeding 3 days per week, and the possibility to work from home 1-2 days per week (pro-rata for part-time staff).

Annual review panels of the College consider applications for promotion, accelerated increments and other performance-related payments from all categories of staff, including fixed-term and part-time staff. Equal opportunities are under continuous review by the College's Equalities Committee and Governing body. The College's Equality Strategy 2012-2016 was approved by the Governors in Spring 2013. There are Equality Leads in all Schools whose role is to raise the profile of equality and diversity in day-to-day operations and to link between the Schools and the College's Equalities Committee. Birkbeck is a member of the Positive for Disability 'Two Ticks' scheme, the Mindful Employer Charter, and a Stonewall Diversity Champion.

Currently 12% of the Department's academic and research staff are women (1 Professor, 1 Lecturer, 1 PDRA) with both women academics being returned to this REF. New female academic staff are assigned a female Probationary Advisor (PrAd). The PrAd of research staff is their research supervisor, so for female research staff we aim to ensure that at least one of their PrAd or their Mentor is a woman. Poulovassilis is a member of the Working Party that prepared the College's successful application for the Athena SWAN Bronze award in 2012 and is now preparing for application at Silver level. Roussos is a member of the School Working Party preparing to apply for the Bronze award in Computer Science, Maths and Statistics in 2014.

The Department's staffing policies aim to fulfil all the conditions of the Concordat to support researchers' career development. Recruiting the highest calibre staff is paramount and, in the case of academic staff appointments, all staff are invited to attend research presentations given by the shortlisted candidates. Once recruited, great focus is placed on staff retention through mentoring, annual PDRs and positive review of promotions (Principle 1). Project team meetings, research seminars and regular social events provide opportunities for peer support. Research staff coming

to the end of their contract meet with their line manager to discuss possibilities for continuing to work at Birkbeck, or opportunities elsewhere. There are mechanisms for providing bridging funding from the School and the Department for research staff who are engaged on specific research programmes (Principle 2). Research staff can apply to the Department for financial support to attend conferences, undertake research visits, follow training courses, and organise workshops and other events (Principle 3). Research staff can contribute to the Department's teaching, and they receive training for this organised by the College and ongoing support from the Department's Teaching Tutor. Support for flexible working patterns is in place (Principle 4). In meetings with mentors and in PDRs, staff are encouraged to identify their training needs and to engage with their lifelong learning (Principle 5). We are a diverse department in terms of nationalities, and all staff with responsibility for recruitment and line management receive diversity and equality training (Principle 6). Review of these procedures is under regular review by the Department and School Research Committees, and the College's Equalities Committee and Governing body (Principle 7).

Research achievements are published on the Department's website, including awards and prizes, successful grant applications, major publications and conference keynotes. This ensures the visibility of such achievements as well as providing a benchmark for the levels of research activity expected in the Department.

The effectiveness of our staffing strategy and staff development processes is evidenced by the promotion successes of academic staff in this REF period: Fenner, Magoulas and Roussos were all promoted to Professor; Li and Wood to Reader; and Di Marzo Serugendo, Helmer, Mikulas and Zhang to Senior Lecturer. Di Marzo Serugendo subsequently returned to her native Switzerland to take up a Chair at the University of Geneva. Li is currently on leave of absence at the Xi'an Institute of Optics. Helmer is also on leave of absence, with an Associate Professor post at the University of Bolzano. We have high rates of academic staff retention, with only two leavers since 2008 (Di Marzo Serugendo and Katsiri, who returned to Greece for personal reasons). The effectiveness of our research staff development is evidenced by the career trajectories of Gutierrez-Santos and Kontchakov who joined the Department as postdoctoral research staff and who were subsequently successful in being appointed to lectureships.

ii. Research students

The Department's research student recruitment strategy places focus on our international and national research reputation in order to attract strong applicants while also fulfilling Birkbeck's mission of offering research degrees by flexible part-time (PT) study. Two full PhD studentships are awarded each year by the Department to full-time (FT) students. Additional fee and maintenance support is available for both FT and PT students so as to attract applicants who may have partial funding from other sources. There are three Teaching Assistant posts whose holders enrol as FT students on the doctoral programme, with full fee remission. The Department also attracts students with scholarships from other countries, e.g. Saudi Arabia, Syria, Thailand, and industry-sponsored students. We offer Masters degrees across all our areas of research expertise (four new Masters degrees have been introduced since 2008) which feed into the PhD programme.

Enrolments have risen from 33 research students in 2008 to 40 in 2013 (as against a rise in application numbers from 42 in 2008 up to a high of 137 in 2011 and 59 in 2013). 20 PhD degrees have been awarded since the 2008 RAE (4 awards in 2007/8 are not shown in REF4a), 12 in CI and 8 in IMWT. Of these 13 were full-time students and 7 part-time. Similar numbers of PhDs were awarded in the previous RAE period. The majority of research students study part-time, with other concurrent commitments. Changing work and family circumstances inevitably result in a lower part-time completion rate. Several students' submissions were delayed in 2012/13 for family, health and work reasons. However, two awards are expected by the end of 2013 (vivas have been passed) and three more PhD theses are submitted at the time of writing (vivas to be held).

To foster a sense of community and to support students' progress, the Department makes special efforts to create opportunities for part-time students to meet with staff and other students in the evening. All training events for research students are held in the evening. Part-time students have access to the same space, computing facilities and conference funding as full-time students.

Each student is assigned a primary supervisor and also a second supervisor who provides a broader or complementary perspective. The Department's Research Committee monitors research students' annual progression, transfer to PhD, and completion. Students submit written progress reports annually and give oral presentations towards the end of their 1st and 2nd years (FT students) or 2nd and 3rd years (PT students). Each student's progress is overseen by a panel

comprising the student's supervisors and one or two additional members. This panel writes a report at each progress and transfer review, to which the student contributes his or her comments.

All research students attend the Department's Research Methods course as well as generic research training delivered by the Birkbeck Graduate Research School and the Bloomsbury Postgraduate Skills Network (BPSN) comprising UCL, Birkbeck and five other University of London institutions. Several members of the Department's staff contribute to the BPSN by delivering annually training in areas such as publishing research, use of specialist data analysis software, and maintaining personal web pages. Research students are offered opportunities to provide teaching assistance on the Department's degree programmes. They receive training for this organised by the College and ongoing support from the Department's Teaching Tutor.

The Department's Research Tutor oversees the academic well-being of research students and has oversight of their induction and research training. Several seminar series and annual departmental Research Days provide students with a broad range of opportunities to become integrated into the research life of the Department and to present their research in an informal setting. The Department provides financial support to students giving papers at conferences, funding the presentation of at least one paper per year for each student, as well as the cost of specialist training, hardware and software as required. The School runs an annual Best PhD Thesis competition and two of our Department's PhD students have won runner-up prizes.

The effectiveness of our research student support and training is evidenced by the career trajectories of our PhD graduates. For example, in this REF period three have attained Lecturer positions at HEIs, one has exploited his research in text modelling and classification to co-found two start-ups, and nine were appointed to new R&D posts in sectors such as advertising, finance, bioinformatics and pharmaceuticals. Brian Gannon's research into the effect of offshoring on the operation of multinational IT firms was directly relevant to his employer, Capgemini. He is now a Director at Kainos and contributes to the teaching of ethical and professional issues on the Department's degrees.

d. Income, infrastructure and facilities

The Department's research activities are undertaken at the Malet Street campus and at the LKL, located 10 minutes walk away in Emerald Street. There are six state-of-the-art research rooms and five research seminar/meeting rooms. Around £20,000 was spent in refurbishing two Malet St. research rooms in 2012. The School provides additional desk space, workstations, social space and a meeting room in its Graduate Centre at Malet St. Around £125,000 was spent in provisioning this new facility in 2012, which is open to research students of all four of the School's departments.

Each new member of academic staff in the Department is assigned a personal office at Malet St. and, for supervisors of LKL-based research, also a desk at Emerald St. Research students, research staff and visiting staff are assigned work space at either Malet or Emerald St. depending on their research area (dedicated space for full-time staff and students, and shared space for part-time). Recent changes in the estates policies of Birkbeck and the IoE mean that Birkbeck's LKL activities will be relocated in the near future to equivalent space in Malet Street and ultimately may be housed in a new research facility jointly owned by Birkbeck and UCL.

In addition to specific equipment purchased for research projects, the Department has two computing infrastructures to meet our research needs, encompassing the Malet St. and Emerald St. sites. We utilise the HTCondor high throughput computing workload management system for compute-intensive jobs. The Condor pool has 512 cores with a total of 1TB of RAM. We also have a Xen server pool with 5 servers (160 cores and 320GB of RAM) and a 10TB storage array. The network infrastructure for the Xen pool is predominantly 10GB Ethernet. All research staff and full-time research students are provided with a new desktop computer (the current standard is i5 CPU with 8GB RAM). Since January 2008 the Department has spent around £80,000 on research computing hardware and software, including around £40,000 in the last two years.

Two systems staff and two administrative staff work in support of the Department's research and research students. In addition, three senior administrative staff of the School manage the School's research processes, research grant portfolio and research-related publicity, and support departments' engagement and research exploitation activities. The College's Research Grants and Contracts Office supports staff in submitting grant proposals and in communication with funders.

Since 2008 the Department has been awarded approximately £1.6M of new grants, mainly from EPSRC, ESRC, AHRC, EU and Government sources. We anticipate that these will continue to be our main sources of external research funding over the next five years, for example targeting

Horizon 2020 and the EPSRC's TI3 priority area. The Department carries out significant amounts of fundamental research for which additional external funding is not needed. Although external research grant expenditure fell in the latter part of this REF assessment period, total external research grant expenditure is 18% higher compared to the previous RAE period. We anticipate a gradual rise in external research grant income over the next five years as our ECR staff (who comprise 42% of staff returned to this REF) become more established: there has already been a doubling of research grant applications in 2012/13 compared with 2011/12 and a successful application for an EPSRC First Grant by Cali.

The Department's professional services range from one-day training and staff development events to longer-term consultancy projects. Recent work includes training events with the British Library and Data Science London; contributions to industry and open-source projects in the areas of software engineering, information management and information retrieval; advising the British Computer Society on the evaluation of degree programmes in IT management; advising on pervasive computing legislation through the ACM Public Policy Committee and the department of BIS; and participation in the international Green IT agenda. The School's Business Engagement and Impact Group works with staff to identify and follow up opportunities for research exploitation.

e. Collaboration and contribution to the discipline or research base

The Department's research groups play a key role in enabling collaborative and interdisciplinary research, for example by sharing members' research contacts, creating networking opportunities, and raising the profile of early career researchers. We collaborate with computer scientists at several other UK universities, e.g. the CI group with Edinburgh, KCL, Liverpool, Manchester, Oxford, Royal Holloway, Swansea, Warwick; and the IMWT group with Bath, Bradford, Glasgow, Herriot-Watt, Imperial, Nottingham, Oxford, Queen Mary, UCL. International collaboration has traditionally been a significant aspect of the Department's research culture and both groups have research links with numerous universities in Europe, USA, Far East, South America and Australia: there are currently some 20 active international collaborations in the CI group and another 30 in the IMWT group. New international collaborations initiated since 2008 by CI group members include with researchers at the universities of Aarhus, Bremen, Budapest Institute of Technology & Economics, CNRS, Genoa, Kyushu Sangyo, L'Institut de la Vision Paris, New University Lisbon, Northwestern Polytechnical University Xi'an, Steklov Institute of Mathematics, Technion, U. of Technology Sydney; and by IMWT group members with researchers at Aarhus, British Columbia, California at Irvine, Chile, Dartmouth College, Electronics & Telecommunications Research Institute (Korea), Modena e Reggio, Politecnica de Catalunya, Cologne, Groningen, Hong Kong, Montreal, Politecnico di Milano, Sao Paulo, Tokyo, Yahoo! Research Barcelona, UCLA, U. of New South Wales. All of these new collaborations since 2008 have led to joint research publications.

There are interdisciplinary collaborations in technology enhanced learning with the Institute of Education, University of Hull, Stiftung Universitat Hildesheim, Ruhr University Bochum and the University of Athens. In bioinformatics and health informatics we collaborate with UCL, the London School of Hygiene and Tropical Medicine, the National Hospital for Neurology and Neuroscience, and the University of Helsinki. Other interdisciplinary collaborations are with Birkbeck's School of Arts and departments of Management, Economics, Mathematics & Statistics and Psychology, and with UCL (Archaeology, Bartlett), LSE, London Zoological Society, Bat Conservation Society, Bath (Engineering), Brighton (Business), Southampton (Business, History), Aegean (Media), Bauhaus (Architecture), Cologne (Media) and Hong Kong (Business). About 15% of the papers we have submitted to this REF are co-authored with researchers from other disciplines.

We participate in the organisation of numerous conferences and workshops: In this REF period staff served as Programme Committee Chairs of the Asian Conference on Computer Vision 2009 (Maybank), Description Logics 2011 (Zakharyaschev), PERCOM 2012, IEEE RFID-TA 2012, IEEE Mobile Cloud 2013 and S-CUBE 2009 (Roussos) and of 11 other international conferences or workshops; and as PC members of 300+ international conferences. Roussos is a steering committee member for the International Conference on Intelligent Environments. Kontchakov was a steering committee member for Description Logics 2009-2012. Cali is a member of the steering committee for Logics in Databases (LID), the management committee of the EU's ICT COST Action IC1302, "Semantic keyword-based search on structured data sources", and the advisory committee of the Next-Generational Financial Cyberinfrastructure Workshop.

Conference keynote talks were given by Cali at DMSSW 2012 and LWDM 2013, Magoulas at ICALT 2013, Poulovassilis at NLDB 2013, Powell at CENTERIS 2010, Roussos at IEEE Internet of

Things 2011 and RFID Live! 2012, and Zakharyaschev at AiML 2008 and TIME 2009.

Kontchakov gave invited lectures at summer schools on Applied Modal Logic (Moscow, 2010) and Semantic Web (St Petersburg, 2012), and Zahkaryaschev at the 9th Reasoning Web Summer School (Mannheim, 2013), ESSLLI 2010 (Copenhagen) and ESSLLI 2011 (Ljubljana).

Powell is Editor-in-Chief of the Information Systems Journal. Zakharyaschev is Editor of the Journal of Applied Logic and Associate Editor of Artificial Intelligence and of Studia Logica. Other indicators of our research contributions (aggregated over current academic staff, since 2008) are:

	CI	IMWT
refereed papers in journals/international conferences/other	77/91/13	84/124/44
keynote talks at international conferences or workshops	9	13
authored or edited books (excluding conference proceedings)	2	5
research seminars at universities in the UK/abroad	22/49	14/37
Journal editorial board Memberships	14	11
Journal special issue Guest Editorships	4	7
EPSRC College members	3	2
reviewing for international research funding bodies	6	7
external examining of PhDs at universities in the UK/abroad	11/3	21/7

Numerous best paper awards have been received: at IJCAI 2011 – Kontchakov and Zakharyaschev; at the 5th Int. Conf. on Web Reasoning and Rule Systems (RR 2011) – Kikot (Postdoc), Kontchakov and Zakharyaschev; at ECIR 2012 and at the 3rd Int. Conf. on Digital Information Management, 2008 – Zhang; at GECCO 2009 – Lewis (PhD student) and Magoulas; at the 11th and 12th Int. Confs. on the Principles of Knowledge Representation and Reasoning (KR 2008 and 2010) – Kontchakov and Zakharyaschev (Ray Reiter best paper prizes). Best student paper awards were received by Mihaela Cocea at KES 2010 and Zaharias Voulgaris at Intelligent Systems 2008. Powell became an Academician of The Academy of the Social Sciences and a Fellow of the BCS in 2011, and an Association of Information Systems Senior Scholar in 2012.

The Department has an Industry Advisory Board comprising senior IT professionals, which meets annually to discuss research and teaching. Opportunities for forging new links with industry are pursued via our networks of professional contacts, including London First, the CBI and the UK Innovation Forum. The majority of our research students study part-time, working concurrently in sectors such as IT, business and finance, and contributing to Department-Industry networks in these sectors. Currently we have active research links with about 20 companies in IT, web search, RFID, automatic identification and data capture, data warehousing, micro-electronics, system software, learning technologies, social media, finance, business development and art (see REF3a), and with many more small firms across a range of sectors through Powell's research in IS.

Much of the Department's research has users or user stakeholders as participants, most notably our research in bioinformatics, pervasive computing and learning technologies. Staff engage with commercial, educational and policy organisations in a broad range of knowledge transfer activities, including presentations and software demonstrations at professional events and museum exhibitions, and training delivered in partnership with IT practitioners. Roussos is a member of the ACM Public Policy Committee (its only European member), Smart Identification and IoT Forum. Johnson (Emeritus Reader) is a committee member and former chair of the UK Computer Conservation Society. Powell was a member of the BCS Management Strategic Panel 2008-11 and the Dutch IT Service Management Foundation up to 2011. Cali is a member of the Oxford-Man Institute of Quantitative Finance. Our LKL collaboration plays a major role in engagement, through events attended by teachers, teacher educators, policy makers, learning technology and media companies, and publishers. The School's annual Business Week showcases the School's research and is attended by members of the public, alumni and professional contacts.

Information Management and Computational Intelligence are critical building blocks for achieving technological innovations in business, science and learning. The Department has a long tradition of contributing theoretical advances, algorithms, architectures, software and empirical analyses, and their novel applications across a range of sectors. Our ongoing strategic aim is to provide a dynamic research environment that affords a rich range of opportunities for staff and research students to develop and exploit their expertise and to disseminate their research findings to their communities of research peers, users and other beneficiaries.