Institution: University of Leicester

Unit of Assessment: UoA 11 (Computer Science and Informatics)

a. Overview

The staff returned with this Unit comprise *all* eligible staff in the Department of Computer Science, which is one of the constituent departments of the College of Science and Engineering. The College is the budgetary unit, and departmental budgets and staffing requests are negotiated with the College. The College also provides direct support for research as discussed below.

The Department concentrates resources and coordinates activities in eight overlapping research *themes*. The themes are an expression of the major research strengths and directions of the Unit, rather than research sub-units. As such, themes do not have designated leaders, although each theme is represented in the departmental Research Committee. The themes are grouped into four *tracks*:

TRACK TCS-A (Theoretical CS: Algorithms and Complexity), includes:

- Algorithm Analysis, Design and Engineering (Erlebach, Fung, Hoffmann, Raman, van Stee)
- Computational Complexity of Algebraic Structures (Hoffmann, Piterman, Thomas).

TRACK TCS-B (Theoretical CS: Logic, Semantics and Theory of Programming), includes:

- Algebraic and Categorical Structures and Methods (Crole, Heckel, Kurz, Petrisan, de Vries).
- Deduction, Rewriting and Transformation (Crole, de Vries, Heckel, Ridge, Tuosto, Ulidowski).

TRACK SE (Software Engineering), includes:

- Models of Software-Intensive Systems (Chitchyan, Heckel, Reiff-Marganiec, Tuosto, Ulidowski, Walkinshaw).
- Software Evolution (Boronat, Chitchyan, Heckel, Reiff-Marganiec, Tuosto, Walkinshaw).
- Verification and Validation (Piterman, Ridge, Tuosto, Walkinshaw).

APPLICATIONS TRACK, comprises the theme Interaction Design and Evaluation of Socio-technical Systems (Chitchyan, Law, Reiff-Marganiec).

b. Research Strategy

The Unit aims to build a coherent and interconnected body of world-class researchers and provide them with a stimulating and supportive environment. Our objective is to enable staff to undertake cutting-edge research in core Computer Science topics and develop new interactions within the subject and across disciplines: within the Department; across the University; and internationally. To achieve these aims, the Department organised itself thematically in 2004, and this has continued over the current assessment period.

Our strategy specifies broad directions of development, and aims to recruit outstanding researchers who can complement existing strengths with new expertise, thus fostering new interactions. The strategic decision to develop the SE Track in 2004 enabled the Department to expand beyond its focus on theoretical CS (as in the RAE 2001 submission) while maintaining a coherent overall vision, and led to a satisfactory outcome in RAE 2008 (mainstream QR income is currently over three times the 2008 level). The improvement in breadth continues to pay dividends: annualised PhD student graduations in this period (~6pa) are well over double that of the previous period (~2.3pa): the same is true of annualised research income. Involvement with industry and other user communities has also increased strongly, thereby helping to address some weaknesses identified by the panel in RAE 2008.

The advantages of the theme-based approach continue to be evident. Firstly, it is flexible: it adapts to changes in the composition of the Unit and its research strategy. For example, following the strategy outlined in 2008, the new theme of *Socio-technical Systems* was created around **Law** (a RF in 2008), and **Reiff-Marganiec**. The hire of **Chitchyan** strengthened both this and the Software Evolution themes. As the Socio-technical Systems theme grew in importance and clarified its identity, it became natural to place it in its own track.

Another significant development—one not envisaged in 2008—has been the creation of a new theme on *Verification and Validation*. The appointment of **Ridge**, initially to complement existing interests in automated theorem proving (**Crole**) and security protocol analysis (**Tuosto**), was followed by that of **Piterman** and **Walkinshaw**, making the creation of this theme a natural

development. This theme is rapidly gaining critical mass and momentum, as evidenced by two recent EPSRC First Grant successes, two Microsoft studentship awards, and two projects funded by the MoD. This development may not have taken place had we focussed on developing areas rather than hiring the best candidates whose expertise was broadly compatible with our vision.

The theme-based approach has also enabled the creation of virtual teams, i.e. multi-talented groups that are set up to address a specific issue such as responding to a call for proposals. This has enabled members of the Unit to contribute to innovative interdisciplinary projects such as *Tracing Networks* (with archaeologists) and *Representing Re-formation* (with art historians).

Finally, since the Department's size makes it difficult to maintain large and autonomous groups, the theme-based organisation makes us less vulnerable to fluctuations in membership. For example, the current structure did not need to be modified upon the departure of **Fiadeiro** (our HoD from 2006-11) to Royal Holloway. The departure of **Yang** (to take up a SL at Brunel), followed by the hire of **van Stee**, led naturally to the folding of the Optimisation and Heuristics theme into the general Algorithms theme, and enriched it with new expertise in algorithmic game theory.

Looking to the future, we recognize that a more hierarchical organisation structure may be appropriate if the Department were to grow to significantly more than its current size. However, there are a number of new themes in which the Department intends to prioritize development while maintaining the current organisation and growth strategy:

- *Data Mining and Machine Learning:* this would complement interests of both **Raman** and **Walkinshaw**, and support work in a number of other themes (including learning analytics and sustainability research, under Socio-technical Systems) and reflects a College-wide initiative to build up this expertise.
- *Cyber-security and Trust:* in this theme, we would be seeking to hire researchers with expertise in one of two directions: either rigorous security analyses of complex distributed systems, complementing the Verification and Validation theme, or human, technological and workplace factors in cybercrime, complementing the Socio-technical Systems theme. This would enable us to address national research priorities including Cyber-security, as well as EPSRC growth areas such as Verification and Correctness and Software Engineering. It would also align with planned College research themes such as the Digital Economy.

c. People, including: Staffing strategy and staff development

The departmental staffing strategy is to use posts either to maintain critical mass and appropriate leadership in the core areas of strength or (particularly if the posts are new, rather than replacement posts) to broaden the research portfolio in line with departmental research strategy, and create links between existing research activities within the Department, College and University. The research areas for advertised posts are discussed by the departmental Research Committee, considering the potential for consolidating existing strengths or expanding into complementary areas in accordance with the research strategy. In cases where teaching requirements dictate a certain area of teaching expertise for a new appointment, the Department still considers candidates with a wider range of research expertise provided the teaching need can be met. This relatively flexible approach allows us to specify broad areas when advertising and to select candidates largely on their merit and this has been instrumental in the creation of new themes.

Support for career development is provided at all levels and can be summarised as follows: *Academic Staff.* The Department has a good record of nurturing promising young researchers. New academic staff are appointed at lecturer level or higher, and are provided with the support and environment needed to enable them to develop their research fully. New staff are assigned research mentors (distinct from teaching mentors), and receive assistance from our Research Officer (see below) in identifying sources of funding. When feasible, new staff (e.g. **Chitchyan, Piterman, van Stee** and **Walkinshaw**) have been given a reduction in classroom teaching, project supervision and administrative load for the first two years of the appointment. This reduction has, for example, helped **Piterman** to develop further his interdisciplinary work at the life sciences interface (see below). We also prioritise new staff when bidding for College PhD

studentships (see below): **Chitchyan** and **Walkinshaw** are each (co-)supervising one such student. Requests to the Department by new staff for conference travel (see below) are judged using more relaxed criteria.
The Department encourages and supports applications for promotions. Recent promotions of lecturers include **Law** and **Piterman** (both to reader) and **Tuosto** (to senior lecturer). Three of the four current professors in the Department originally joined the Department at more junior levels (one as lecturer–**Thomas**, and two as readers–**Erlebach** and **Heckel**).

Support available to all academic staff includes the following:

- Staff can request support for travel to conferences to present papers from the departmental recurrent budget. The Department has spent in the region of £25K pa, averaged over the last three years, in supporting such travel: the College has been supportive of such needs during negotiations of the recurrent budget. The majority of this expenditure has supported attendance at high-profile refereed conferences leading to a returnable output (e.g. **Crole**, MFPS 2013**, Erlebach** SODA 2008, **de Vries**, RTA 2012, **Raman** ICALP 2012), though exceptions may be made for junior staff, or where attendance has strategic importance (e.g. attendance at Dagstuhl workshops by **Piterman** and **van Stee** among others). Other necessary conference travel is also supported this way: e.g. attendance of conference PC (co)-chairs such as **Piterman** (TACAS 2013) and **Ulidowski** (CONCUR 2012).
- Study leave is supported on a regular basis for members of staff, giving staff the opportunity to develop their research and also to prepare grant applications. Study leave requests are evaluated based on a research plan and expected outcomes in terms of publications and grant applications. In the assessment period, 13 one-semester study leaves and two two-semester study leaves have been granted. A number of outputs returned have been a direct outcome of study leave, including **Boronat** (FoSSaCS 2013), **Crole** (MFPS 2013), **Erlebach** (ACM Trans. Alg. 2008, Theory Comput. Syst. 2008), **Fung** (J. Scheduling 2013)**, Hoffmann** (STACS 2008), **Raman** (ICALP 2012) and **Ulidowski** (MSCS 2012, CONCUR 2013).

This kind of support has enabled us to return all eligible staff in the Department in REF2014.
A proportion of overheads, as well as research and consultancy income, is returned by the College to the Departmental Development Fund (DDF). The DDF is used for a variety of purposes. It has been used to offer a departmentally-funded independent research fellowship (held by **Petrisan** from October 2011 to August 2013) and to provide match-funding when applying to the College PhD scholarship scheme (see below). DDF income is shared with PIs, who use their share to support incoming visitors, for travel during study leave and similar expenditure.

Research Staff. The University is a signatory to the Concordat to Support the Career Development of Researchers and has recently been awarded the EC 'HR Excellence in Research Award' in recognition of its commitment to its Action Plan from 2011-2013. The Department supports this Action Plan, and strongly encourages, for instance, items such as allowing research staff to publish research results independently of their supervisor(s). Research staff routinely provide lectures and tutorials to develop their skills, and are encouraged to attend the training provided by the University's Academic Practice Unit.

Generic support for staff involved in research includes:

- An annual "away day" ito discuss research strategy, disseminate best practice, provide opportunity for starting new collaborations, and related research issues.
- The Academic Practice Unit provides a focussed programme of research training for researchers at all levels, from PhD students to leaders of large research programmes. Built upon Vitae's Researcher Development framework, the training is organized under four core programmes: Research Leadership and Management, The Enterprising Researcher, The Intrepid Researcher and Skills for the Professional Researcher, as well as technical training in HPC, e.g. MPI and CUDA. Academic and Research staff, as well as PhD students, are encouraged to attend relevant courses, and many benefit from such training.
- The Research Support Office and the Enterprise and Business Development office organize visits by funders, and "how to" events, such as "Finding Research Funding",

"Commercialising Your Research" or "Managing Budgets on Research Projects", either as stand-alone events or as annual "Research Focus Week" events.

- Both academic and research staff have annual appraisal meetings with the Head of Department or other senior academics, and short-term and long-term career development (including research as an important item) is routinely discussed at these meetings.
- A departmental Research Officer alerts and advises staff on funding organisations and schemes, liaises with the Research and Personnel Offices, maintains an archive of submitted applications (as exemplars) and advises on costings and related application issues.
- We hold two series of weekly seminars: Friday seminars are normally given by an external speaker and aimed at a broad CS audience. Thursday seminars are typically focussed on one of the eight themes. Ad-hoc seminars and reading groups are often organized around research visitors or project meetings, or along existing or nascent themes—for example, there are currently reading groups on Coalgebraic Logic, Data Mining and Software Engineering for Sustainability.

International Staff Appointments. By specifying broad areas of interest while recruiting, and focussing on the excellence of the individual, rather than details of research areas, we have fielded strong applications from around the world. In this period, we appointed **Law**, **Piterman**, **Razgon** (now at Birkbeck) and **van Stee** to their first lectureships in the UK (all four obtained their PhDs overseas, and had significant international research experience prior to coming to the UK). **Tuosto** was appointed a visiting professor at Cagliari. There is a regular stream of academic and industry visitors to the Department, in the context of seminars or smaller meetings organized by the Department. Longer-term visits include Balan (Bucharest), Bracciali (Stirling), Bodei (Pisa), Honghui Chen (National University of Defense Technology, Changsha, China), Clouston (ANU), Kepka (Prague), Kinyon (Denver), Melgratti (Buenos Aires), Montangero (Pisa), Moshier (Chapman), Nies (Auckland), Orejas (Barcelona), Pombo (Buenos Aires), Satti (Seoul), Y. Tabei (Tokyo Institute of Technology) and Jiuyun Xu (China University of Petroleum).

Equalities and Diversity. We have an active and high-profile Equal Opportunities Co-ordinator, who supports the Head of Department in formulating and implementing policy in this area. Anyone with equality concerns is regularly encouraged to raise them with her; she also attends all staff meetings, where the agendas always include an update/discussion on equality issues. Events that promote and support equal opportunities are actively publicized and a small budget has been made available to pay travel costs for students interested in attending external events that promote women in STEM subjects. The Department was awarded the Athena SWAN Bronze award in 2013, and intends to apply for a Silver award soon. As concrete examples of our support of equality, the Department has assisted staff with specific family commitments (most recently **Chitchyan**, **Piterman** and **Walkinshaw**) to work flexibly.

c. II. Research students

We have maintained the high levels of support for research students, while streamlining mechanisms for recruitment, support and monitoring PhD students to deal with increased numbers. The number of institutionally-supported PhD students has increased significantly in this REF period, mostly due to the increase in Graduate Teaching Assistant (GTA) posts: we now have a steady-state complement of 12 GTAs, up from 3 GTAs in 2008. A GTA is supported for four years of full-time PhD study. A number of GTA posts become available each year: this predictability, together with flexibility regarding the research area, is helpful in attracting strong applicants. In addition, the College operates a competitive scholarship funding scheme for PhD students (match-funded from the departmental DTA allocation, or the Departmental Development Fund) which has supported some CS students. When prioritising applications at departmental level, preference is given to applications by new staff and applications that are either interdisciplinary or foster new connections. Examples include the studentships awarded to **Chitchyan** and **Walkinshaw** (new staff) and **Law** (joint project with the Department of Media and Communication, to start 2014). **Walkinshaw**'s student is co-supervised with **Raman**, helping to develop their emerging interests in the general areas of data mining. All funded studentships are advertised and undergo a formal selection process, involving formal

shortlisting, visits by candidates and interviews.

The University's Graduate Dean is a member of the University senior management team indicating strong institutional support for this role. Each PhD student:

- Has two supervisors (one in a mentoring role);
- Gives at least two seminars to a general departmental audience, in addition to less formal presentations;
- Undergoes a formal annual process of progress monitoring and planning, and consistency of treatment across supervisors is ensured by a tri-annual meeting of a departmental PhD monitoring committee;
- Completes an annual "passport" that details general and transferable skills training.

Training is addressed by:

- Offering regular departmental “PhD short courses” that introduce students to the research areas pursued in the Department. Here, the theme-based organisation is particularly helpful in exposing PhD students to a variety of viewpoints and techniques. For instance, the courses in the Autumn 2013 term are “Logic, set theory and theorem proving”, “Algorithms based on linear programming” and “Dynamic system reconfiguration using policies”.
- Funding students’ attendance at “summer” schools (including the Midlands Graduate School in Foundations of CS, described in greater detail under “Collaboration”);
- Encouraging students’ attendance at termly workshops focussing on generic research and transferable skills training organized by the College (the broad range of topics includes, e.g. “basics of Literature review”, “preparing for Probation review”, ”The Language of the Scientific Thesis”, “Preparing for the Viva Voce Examination”, “IP and its Commercialisation”, “Research vs Non-Research Careers”), or at the workshops offered by the APU for research staff;
- Encouraging participation in academic writing workshops run by the English Language Teaching Unit for students whose first language is not English;
- Supporting an active seminar series managed by PhD students, which hosts students from other universities as speakers;
- Giving PhD students the opportunity to provide teaching assistance in lab sessions and tutorials, thus gaining experience in teaching.
- Providing funding for students to participate in/present papers at international conferences: the vast majority of our students have at least one (or more) papers and presentations in international refereed conferences by the time of graduation.
- Encouraging presentations to wider audiences. For example, in each of the years 2008-2013, a PhD student from the Department has given talks at the “Postgraduate Research in Computing" event organized by BCS Leicester Branch, and several students have presented posters at the Annual “Festival of Postgraduate Research” organized by the Graduate School.
- Organising a termly PhD student-staff committee where (inter alia) issues relating to support and training, or physical, library and computer infrastructure can be raised.

A GTA, in addition to being a PhD student, is also a (0.2FTE) member of staff. As such, GTAs have a greater degree of autonomy when undertaking teaching assistance, and are also involved in other departmental teaching-related activities such as UCAS days, or developing software to support teaching, thus preparing them particularly well for a career after graduation.

The principal mode of training, however, is by research under the direct supervision of a member of academic staff. It is notable that several outputs that have been returned have been co-authored by a PhD student and his or her supervisor (e.g. [**Crole** 3], [**Heckel** 3, 4], [**Tuosto** 1]).

d. Income, infrastructure and facilities

The current research profile requires relatively little investment in specialist facilities. Mainstream infrastructure (including software licenses) is funded through our recurrent budget. Specialist equipment, such as an eye-tracker to support work in software usability and user experience, has to date been funded from appropriate research projects. We have access to a centrally-provided HPC cluster (ALICE), which has been used, for example, for research into evolutionary

algorithms**,** to simulate hundreds of users using an algorithm to re-modularise software systems, and to experiment with test set generation algorithms. Established using a £2M CIF award, ALICE has recently been given a £850K upgrade. The library continues to invest in electronic resources, and in an institutional repository, the Leicester Research Archive.

The annualised research income in this period is over twice that in the RAE 2008 period. We are seeking to further grow European funding (by targeting suitable Horizon 2020 calls) and charity funding, and to improve RCUK funding, which proportionally is lower than we would like. One of the mechanisms we have introduced to support this is internal review of applications. All significant grant applications made by members of the Department must undergo internal peer review. Several staff in the Department have experience in the reviewing of grant applications for various funding agencies, and some have experience as members of grant awarding panels (see Section e for details). Authors of grant applications can either approach experienced colleagues directly or ask the Head of Department or the Research Committee Chair, who then assigns an internal peer reviewer. Staff can also get advice from experienced staff in other departments. For example, an application for a Marie Curie Initial Training Network by **Law** benefited from advice from a successful applicant from another Department (Baltzer, Geography). The Research Support Office regularly organises sessions where successful grant applicants talk about their experience, give advice, and answer questions.

The Department has actively engaged in Innovation Partnerships and KTPs; staff participation is encouraged via financial incentives. This has led to 13 IPs and KTPs in the last 3 years, with about £115K spent on a combination of consulting, secondments and training. To develop and support activities of this nature, the role of a departmental Business Fellow (**Reiff-Marganiec**) has been created, whose task is to engage with companies who contact us (or to approach companies that we think could benefit from working with us), in order to scope the potential for research collaboration. In the future, we aim to further target industry collaboration in areas that relate directly to our research interests and expertise. Our objective here is to enhance the potential for research outputs resulting from collaborations and for impact of our research.

e. Collaboration and contribution to the discipline or research base

Our theme structure gives us an interest in a broad spectrum of research areas when we advertise posts, and a bias towards candidates who complement, rather than strengthen, existing expertise. Consequently, we have rarely, in the last ten years, appointed a candidate who has had significant prior research collaboration with an existing member of staff. The Department is inherently outward-looking as a result.

We have strong links with several **UK universities**, evidenced by joint projects and publications, including: St. Andrews (**Thomas**), Birmingham (**Kurz**), Cambridge (**Ridge**, **Piterman**), Imperial (**Piterman**, **Tuosto**, **Ulidowski**), Lancaster (**Chitchyan**), Newcastle (**Law**), Open U. (**Law**), Sheffield and Southampton (**Walkinshaw**) and Warwick (**Hoffmann**, **Thomas**). Leicester is a founding member and leading contributor to the Midlands Graduate School in the Foundations of Computer Science (MGS) held each spring, offered jointly with Birmingham, Nottingham and Sheffield. MGS has been supported by EPSRC and was organized at Leicester in 2009 and 2013. **Crole** has recently (November 2013) been appointed Director of the MGS for a period of three years.

International collaborations are numerous and varied. Particularly strong collaborations—again evidenced by joint publications and projects—are with RWTH Aachen (**Law**), ILLC Amsterdam (Kurz); Auckland (**Thomas**); IST Austria (**Piterman**); UPC, Barcelona (**Boronat**, **Heckel**); Buenos Aires (**Piterman**, **Tuosto**); Cagliari (**Tuosto**); Chalmers (**Crole**); City University of Hong Kong (**Fung**); Copenhagen (**Law**); Eindhoven (**Ulidowski**); Haifa (**van Stee**, **Raman**); Iceland (**Law**); Autonomous University of Madrid (**Boronat**); LMU Munich (**Heckel**); Illinois, Urbana-Champaign (**Boronat**); UC Louvain (**Walkinshaw**); Max Planck Institute for Informatics (**van Stee**, **Raman**); Nagoya (**Ulidowski**); Pisa (**Heckel**, **Raman**, **Reiff-Marganiec**, **Tuosto**); Prague (**Kurz**); Porto (**Thomas**); Rice (**Piterman**), Roma Tre (**Erlebach**); Seoul National University (**Raman**); SINTEF, Norway (**Chitchyan**, **Law**);Technion (**van Stee**); Waterloo, Canada (**Raman**) and ETH Zurich (**Erlebach**, **Law**). International collaborations are supported in a number of ways. In addition to external funding sources, for example, involvement in EPSRC or European research projects; travel-only grants from the London Mathematical Society

(LMS), Royal Society, JSPS or Marie Curie actions, we make support available from the Departmental Development Fund. The periods of sabbatical leave mentioned above have facilitated longer-term visits to collaborators.

Research links with industry and government bodies—again based on joint projects or publications—include ATX Software (**Heckel**); Critical Software and DSTL (**Walkinshaw**); Microsoft Research (**Ridge**, **Piterman**); Nokia and Philips (**Law**) and Thales (**Chitchyan**).

Interdisciplinary research is strongly encouraged and supported within the Department, and the Department has contributed to several innovative interdisciplinary projects. A notable example is the major role played by the Department in the £1.75M project *Tracing Networks* funded by the Leverhulme trust, and led by the School of Archaeology and Ancient History. Within this project, the computer scientists' contribution included: to map techniques arising from cultural and "technological" craft networks of ancient civilisations to modern distributed computation paradigms, to apply computer science techniques to provide a logical framework to aid classification and analysis/interpretation of data and to provide an integrated collaboration framework. The Computer Science staff involved cut across themes and included **Fiadeiro** (currently at Royal Holloway), **Law** and **Tuosto**, as well as RAs **Bocchi** and **Hong.**

Work in the Socio-technical Systems theme is intrinsically interdisciplinary. In particular, through this theme the Department contributes to the *Representing Re-Formation* project (funded by the EPSRC and AHRC) that is led by the Department of the History of Art and Film, as well as the EU projects ROLE (Responsive Open Learning Environment) and Go-Lab (Global Online Science Labs for Inquiry Learning at School).

Work on applying model-checking techniques for understanding cellular stabilization, an approach called "executable biology", by **Piterman** and colleagues has not only led to new biological insights (published in the Nature group journal *Molecular Systems Biology* in 2012), but has also led to their developing new procedures for model checking applied to biological models, presented at VMCAI 2011, CAV 2013 and POPL 2013. It also underlies a tool, described below.

The College encourages and facilitates the formation of interdisciplinary research themes: College support for such themes includes funding to arrange workshops, kick-off meetings, or coordinate grant proposals. The Department, for example, is an active participant in the Mathematical and Computational Biology sub-theme of the College Life Sciences Interface theme. As mentioned earlier, a cross-college Digital Economy theme is planned.

This interaction with users and industry partners has had an important influence on our research. One example is the collaboration with ATX technologies SA, which began with the Leg2Net EU project in 2004-08 This cooperation has been genuinely synergistic, with a number of research outputs co-authored with ATX employees such as **Matos** (a PhD graduate), ATX providing case studies for use in re-engineering research and in influencing a line of research by **Fiadeiro** (who left Leicester in 2012) and colleagues in FASE 2011 and ECSA 2010 for instance.

An important outcome of **Law**'s work with researchers from Nokia and Philips in the area of User Experience (UX) is the "UX White Paper" (http://www.allaboutux.org/files/UX-WhitePaper.pdf), co-authored by the participants (of which one-third were practitioners/industrial researchers) of a Dagstuhl Seminar co-organized by **Law**. The White Paper presents an integrated understanding of UX and requirements for UX design and evaluation methods from industrial and academic perspectives, and has shaped the direction of Law's research, in particular, her studies on the measurement of UX. This paper, together with other resources on UX research is publicly accessible on the "All about UX" website (http://www.allaboutux.org) and provides a continuing forum for academic/industrial collaboration for **Law** and her colleagues.

A third example is the Bio-Model Analyzer (BMA) tool for illustrating signalling pathways and determining cellular stabilization, developed by **Piterman** and collaborators at Cambridge and Microsoft Research, which relied extensively on feedback from end users for its development. BMA was introduced at CAV 2012 and the development process was presented at CHI 2013.

Finally, in the SiXML project (http://www.cs.le.ac.uk/SiXML/), which seeks to apply succinct data structures to XML processing, there has been regular interaction with the XML developer

community (through poster presentations and "demo jam"s at XML Prague in 2009, 2010, 2012 and 2013 for example). Feedback from this community has spurred research work by **Joannou** (PhD student) and **Raman** on practical methods for dynamizing succinct data structures, presented at SEA 2011 and 2012.

The Department has contributed **leadership in the academic community** in a number of ways. For example, **Thomas** has contributed to developing the Mathematics/Computer Science interface through his involvement with the LMS, as chair of the LMS Computer Science Committee and member of the LMS Council (until end 2008) and will continue to do so as a member of the LMS Research Policy Committee (from October 2013). **Heckel** was elected President of EASST (European Association of Software Science and Technology) in 2012. **Ulidowski** has helped to establish a new conference in Reversible Computation and (co-) chaired the first two instances of this meeting in 2009 and 2010.

Leadership is also manifested by:

- Membership of, or chairing, the **Steering Committees of international conferences**: **Heckel** (ICGT SC Chair 2008-, FASE 2005-, FASE SC Chair 2006-2008, ETAPS 2006-2008, 2013-), **Raman** (ALENEX, 2006-) and **Ulidowski** (Reversible Computation, 2009-) and IFIP working groups (**Kurz**, **Heckel** and **Ulidowski).**
- **(Co-)chairing major conference programme committees: Erlebach** (WG 2008, Track B of ALGOSENSORS 2011 and WAOA 2012), **Heckel** (CALCO 2013), **Kurz** (CALCO 2009, TACL 2013), **Law** (CHI 2012, 2013 Associate Chair), **Piterman** (TACAS 2013), **Reiff-Marganiec** (ICFI 2009) and **Ulidowski** (CONCUR 2012).
- **Peer-review of funding and funding programs** in the UK and internationally. **Erlebach**, **Heckel**, **Raman** and **Thomas** have all been on the EPSRC College of Reviewers since 2008, and **Heckel** and **Thomas** have served on prioritisation panels in this period. **Raman** has served on the Royal Society Newton International Fellowships panel from 2010 (renewed until 2016). Internationally, **Erlebach** served on a site review panel for the Science Foundation of Ireland (September 2008), reviewed grant proposals for major Greek programmes such as "Thalis" (January 2011 to August 2011) and "Archimedes III" (December 2010 to August 2011), served as a member of the review panel for the German Research Foundation (DFG) Priority Programme on "Algorithm Engineering" from 2007-2013 and is also a member of the new DFG Priority Programme on "Big Data" (the first prioritisation panel meeting will be in December 2013). **Erlebach** and **Law** were members of a prioritisation panel of the Portuguese Science and Technology Foundation (FCT) in July 2011. **Thomas** was a member of a six-strong international review and prioritisation panel for the Academy of Finland and the Research Council for Natural Sciences and Engineering in 2012 that considered and made decisions on the research funding to be allocated in Mathematics in Finland that year. **Thomas** also was an external reviewer for the Greek "Archimedes III" programme.
- Membership of **Editorial Boards** of journals: **Erlebach** (*Theoretical Computer Science, Operations Research Letters*), **Law** (*Interacting with Computers*), **Raman** (*J. Discrete Algorithms*) and **Thomas** (one of three editors of the *LMS Journal of Computation and Mathematics* and on the editorial board of *Groups, Complexity, Cryptology*). **Chitchyan** was the guest editor of an issue of *Transactions on Aspect-Oriented Software Development* in 2009. In addition, **Heckel** is on the advisory board of the EATCS series *Monographs in Theoretical CS*, published by Springer, and **Ulidowski** on the editorial board of the series *Electronic Proceedings in Theoretical CS*. **van Stee** is an editor for *SIGACT News*.
- **Law's chairing of EU COST actions** MAUSE (2005-2009, http://www.cost294.org/) and TwinTide (2009-2013, http://www.twintide.org/).
- **Keynote addresses** include **Kurz** (British Logic Colloquium, 2010), **Law** (EICS 2011), **Piterman** (MFCS 2013), **Raman** (IWOCA 2012, ALSIP 2011), **Thomas** (International Conference on Semigroups and Applications, Uppsala, Sweden, 2012 and International Conference on Algebra, Balikesir, Turkey, 2013) and **Tuosto** (WS-FM 2012).

As a Unit we have developed significantly since 2008, with increased income, strong outputs, more PGRs and greater industry links.