Institution: The University of Huddersfield
Unit of Assessment: 11 Computer Science and Informatics
a. Overview

The submitted Unit is based in the Department of Informatics. Staff entered in the Unit are drawn from the University's Centre for High performance Intelligent Computing (CHIC). Intelligent, high performance, reliable computer systems are fundamental to solving grand challenges in areas such as transport, health, security and energy. The Centre aims to research and develop new methods and technology in computer science that will underpin solutions to these major societal challenges. Computer systems underlie the fabric of modern society, from entertainment to energy supply, communications to commerce. In addressing the major societal challenges of today, the key limitations of current computer technology have to be solved before it can provide the carrier for these challenges' solutions. The Centre focuses on three aspects fundamental to the success of future computer systems, and these form subgroups of the submitted Unit:

- **SUB-GROUP A:** PARK: Planning, Autonomy and Representation of Knowledge group (submitted staff: Grigoris Antoniou, Lee McCluskey, Patrick Doherty, Wolfgang Faber, Mauro Vallati, Lukas Chrpa, and Andrew Crampton) research into the theory and application of artificial intelligence, specifically knowledge representation, knowledge engineering, and automated planning.
- **SUB-GROUP B:** VIV: Visualisation, Interaction and Vision group (submitted staff: Zhijie Xu, David Peebles, Devina Ramduny-Ellis, and Nadia Ali) research aims focus on the seamless communication between humans and computer systems. Examples include the use of image processing to detect security threats from CCTV and the application of cognitive and engineering psychology to investigate and facilitate human behaviour in socio-technical systems. One of the group's leaders (Dr David Peebles) is a cognitive scientist based in the School of Human and Health Sciences.
- **SUB-GROUP C:** ISE: Information and Systems Engineering group (submitted staff: Joan Lu, Vassilis Christophides, Di Cai, Sotirios Batsakis, Colin Venters) is aimed at solving research challenges in managing, processing and retrieving information from large amounts of data, in particular in those areas concerned with web technologies.

b. Research Strategy

Over the past two decades, the internet and mobile computing have revolutionized almost all aspects of the economic and social activities in modern countries. Recent technological developments in information technology have seen the deployment of sensors and small computing units in a vast variety of settings, and the generation of huge amounts of data from sensor data and social networks. The first development is enabling the creation of *smart environments* through the combination of mobile computing, intelligent methods and human-computer interaction, with applications ranging from smart homes, smart work spaces, smart classrooms and ambient assisted living. The second development has become known under the term *big data*, and poses significant challenges in terms of storage and retrieval, efficient processing to derive higher-level information from low-level data, and linking semantically heterogeneous sources of information. These challenges often reach the limits of traditional information technology systems, and are often met using *high performance computing* approaches and infrastructures. The promise of big data is that we are at the beginning of an era where data, often in the form of open data, is considered as a resource that can be combined with other information to enable value adding services; *a data-driven economy*.

These general developments and challenges lie at the heart of the informatics research strategy at the University of Huddersfield, and the research focus of our strategy is consistent with the three research groupings of PARK, VIV and ISE. Future research activity in the Unit will utilize high performance methods and infrastructures, among others, to reason with and semantically process huge amounts of imperfect (inconsistent, incomplete, noisy) data. Our research plans include the development of methods for complex processing of huge amounts of data over HPC Infrastructure within intelligent transportation, e-health and smart cities.

The aims of our strategy over the next five years are to:

(i) recruit and develop excellent PGRs of increasing numbers to a figure of around 2 x number of department staff FTE, evidenced through PGR external engagement, completion rate and future career progression;

(ii) create, by recruitment and development, a body of excellent staff researchers, evidenced by research income, research publications, and the permeation of research ethos throughout the Informatics Department. This entails that, within five years, the Unit's three groups will be self-sufficient in funding, and over 90% of departmental staff will be research active;

(iii) double our research outcomes at internationally excellent standard, and double our impact via the effect on the solution of the challenges referred to above, and evidenced by at least a doubling of excellent impact case studies in the next five years.

These aims, centred on research growth, are in line with University policy to establish itself as being research led by 2020. The School, and its Informatics Department, has followed University strategy, transforming its research output over the REF period. The evidence for success can be seen by examining statistics in 2008 vs 2013; in all categories we have grown by factors of between 2 and 5: proportion of staff with PhDs (growing from 35% in 2008 to 75% in 2013), funding, PhD students, number of research active staff, number of research fellows To help strategic direction, by providing feedback on our objectives and mechanisms, we have enlisted an international panel of experts to help review our research strategy, benchmark our research against other institutions, and give us informed directional advice: Prof Ian Horrocks (Oxford), Prof Frank van Harmelen (Free University of Amsterdam), Prof John Mylopoulos (Trento), and Prof Fabio Ciravegna (Sheffield). The International Panel met on April 29th 2013, and are meeting again on November 22nd, 2013, to discuss and feedback on progress towards our strategic aims.

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c. People, including: Staffing strategy and staff development, and Research Students

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The context for the development of researchers is set by national initiatives, e.g. the national benchmarks provided by the RCUK's Researcher Development Framework, and the code of principles within The *Concordat to Support the Career Development of Researchers.* Our Concordat Steering Group, chaired by the Pro-VC for research, is implementing the Concordat to ensure we comply and exceed all areas within it, and in the context of such initiatives we will deliver a step change in the careers development of research staff. In 2011 the University was granted the HR Excellence in Research Award by the European Commission in recognition of its implementation plan and progress to date. We give specific evidence below that the mechanisms we detail are working, but there is more general evidence: in 2011 Huddersfield overseas students voted us best University in the world for student experience in the International Student Barometer; and in 2012 we won the Times Higher Education Award of Entrepreneurial University of the Year, with a submission that emphasised innovation in research and enterprise.

There is a range of mechanisms we use to promote an excellent research environment, and in particular as we go forward to support our Strategic Aims of (i) and (ii):

- **Cultural Environment:** Since 2009 the Unit's research has been celebrated and disseminated to all University students, staff, the wider academic community, and business, via the annual *Research Festival*. This is a week-long University-wide event within which the Unit's members give research talks, demonstrations and facilities tours about its research. The School runs a one day annual *Researcher's Conference* aimed specifically at research students (PGRs), their supervisors and their sponsors. This gives students the opportunity to submit and get reviewed a scholarly paper, to present their work in a conference atmosphere, and is another opportunity to showcase the Unit's work. Each year there is a *Postgraduate Researchers' Day*, where students from all over the University can meet, hear talks from distinguished researchers, and discuss research issues. Within the Unit, in particular, each of the research groups has a weekly, formal timetabled slot when all members of that group are free, to enable them to meet for seminars and meetings.

- **Student Pastoral Support and Graduate Centre:** Each PGR student has a supervisory team and a personal tutor to guide them through their studies. There is a University-wide schedule of progression monitoring for all students: to progress from one year to the next PGRs have to submit and end of year report, and present an oral, in front of an examination panel. Attached to this progression are milestones including the official recording of

> Programme of Research; Personal Development Planning and Review; Research Progression Advice; and Student Feedback. With both a physical and a virtual presence, the University's *Graduate Centre* provides both intellectual and social contact between postgraduate researchers of different disciplines and from different backgrounds and countries. Similar opportunities exist within the Unit, for example PGR *Ms Falilat Jimoh* acts on a part time basis as the administrator of the Unit-run COST Network Action called "ARTS", which entails liaising with academics from 24 European countries.

- **Funding Support:** There are a range of central *internal funding support mechanisms,* established in their present form in 2010, aimed at supporting both PGR students and early career research staff to engage in the external research community, supporting our strategy for global research engagement. This includes funding for conference presentation, networking, public engagement, intellectual climate activities. In 11/12 alone, £42,000 was spent to support PGRs and staff in the Unit. For example, the conference presentation was used to support PGR *Simon Parkinson's* travel to ICAPS 2012 in Brazil to present his paper. The Research Networking Fund, used for planned visits to centres of research excellence, enabled ECR *Dr Lukas Chrpa* to visit the Icelandic Institute for Intelligent Machines (IIIM) and the Center for Analysis and Design of Intelligent Agents (CADIA) at Reykjavik University, for 2 weeks in April 2013.

- **PGRs Awards and external engagement:** the School and University have set up annual research awards, e.g. the Vice-Chancellor's Prize for an Outstanding Doctoral Thesis, and the Vice-Chancellor's Prize of PGR Student of the Year. *Dr Jing Wang*, one of the Unit's PGRs and now a research assistant in the VIV group, was shortlisted for an award at the [2011 ICT Pioneers Competition](), taking place in London, and he finished second in his category (Technology Tsunami); while PGR *Ilias Tachmazadis* of the PARK group was first author of the RuleML 2013 Best Paper Award for his paper entitled: "Computing the Stratified Semantics of Logic Programs over Big Data through Mass Parallelisation" http://2013.ruleml.org/content/program-and-accepted-papers.html.

Our **Staffing strategy, development and support** are aimed at supporting our Strategic Aims, particularly (ii) and (iii) above:

- **Staffing policies and mentoring:** every member of staff is a member of a research group within the Informatics Department, and in this context *staff appraisals* set and monitor research goals yearly, in conjunction with the aims of individual groups. We have introduced new schemes of PhD by Published Work or PhD by Portfolio to assist any staff without PhDs. A necessary condition for new academic staff to be recruited is that they have to the potential to be an excellent researcher.

- **Support Staff Professionals:** The School has 3 FTE research support administrative staff, and there are teams in the University centre which monitor and assist in disseminating research calls, pre-award costings and post-award grant management. They organise around 40 short courses run each year to help develop the skills within academic research staff, research supervisors and PGR students. For example, professional support led directly to one of our department staff, Dr Christopher Newman, winning his first award in 2013, entitled "Energy-Efficient Computing", from the TSB with a total Funding Value of £130k.

- **Virtual Environment:** There are a range of software services to support research and researchers: *ePrints*, eprints.hud.ac.uk, a comprehensive research repository, is a one-stop store for research outputs – for example internal personal and research group websites are automatically updated with new publications placed in ePrints. It is promoting the impact of our research, with a growing number of items and downloads. Linked to ePrints and partly funded by Unit-supported JISC projects, is a research information management system (the "*RIMS*") which supports research managers with information and analysis. We also maintain a *Research Intranet,* a comprehensive intranet-based information system which is the first port of call for researchers when seeking any information, from official forms, to how to get support when applying for funding.

- **Equality and Diversity**: The University's policies and procedures for promoting equality and diversity are kept under constant review by the Concordat Steering Group and the

University's Senior Management Team, which together manage our relationships with, and programmes inspired by, key partners such as Athena SWAN, Project Juno and Stonewall. This is supported in the Unit via our involvement in the implementation of the RDF and the Concordat as mentioned above, for example through research leadership attending E&D courses, and department involvement in external E&D initiatives. In particular, stff member Dr Duke Gledhill took part in the preparation of the University's Athena SWAN Bronze University Award submission; and submitted staff member Dr Devina Ramduny-Ellis is a member of the University Athena SWAN Assessment panel. Devina is also active in the University's Women's Network Group, which organise supportive activities for women researchers.

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d. Income, infrastructure and facilities

The Unit has benefitted from a significant investment in underpinning infra-structure for research during the REF period, in order to achieve our aims of transforming ourselves to a research – led institution. This includes the School's £8 million EPSRC Centre for Innovative Manufacturing in Advanced Metrology, Strategic partnerships with Siemens, The Prince's Trust, 3M and Local Council-backed £12 million ERDF-funded 3M Buckley Innovation Centre (opened 2012). In 2010 the University invested £475,000 into HPC hardware and software infrastructure over three years, which led to establishing the University of Huddersfield Campus Grid QGG, affiliate membership of NES(NGS) National e-Science Systems, membership of NWG and HPC and Campus Grid-SIG, and a partnership with STFC creating a cloud based on the iDataPlex system. These developments underpin our strategic focus on HPC (see section b). For example, members of the PARK group are organising the deterministic track of the 2014 International Planning Competition http://ipc.icaps-conference.org/. Using our HPC equipment, we have set up 60 virtual machines for competitors to remotely install their software entries, and we will use the HPC devices to evaluate these competition entries.

We have invested significantly in new research-oriented staff, leading to an unprecedented growth in numbers (Professor G. Antoniou in February 2012, Professor P. Doherty (part time) in September 2013, Dr W. Faber in September 2013, Dr S. Batsakis in September 2013 and Prof. V. Christophides (part-time) in October 2013; as well as five new departmental research fellow posts set up since 2011) transforming our research environment with the infusion of new blood, a balanced combination of senior and early-career, research-focussed staff. Likewise, the Unit has benefitted from PGR training investments over the REF period, resulting in the population of research students growing significantly as shown in the accompanying statistics.

Support and investments detailed above have led to recent research grant acquisition which in themselves are increasing outputs and research networking, and are helping sustain our strategy. Currently staff in the Unit have acquired grants in the last 3 years totalling over £1m, in particular from the EU: **ARTS** (2011-15) COST action TUD1102; worth c.Euro 500,000; **PRELIDA** (2013-14) co-ordination action worth Euro 130,000; **SemData** (2013-17) IRSES action worth c.Euro 100,000; and from the EPSRC **Hedlamp (2012-2016)** worth £366,000. This new income supports both infrastructure and staffing, and networking of researchers, and is indicative of the growth demanded by (iii) in our Strategic Aims.

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e. Collaboration and contribution to the discipline or research base

<u>**Exemplars of Collaboration:**</u>

- **Lee McCluskey** is Chair of the interdisciplinary COST action network TUD 1102 "Autonomic Transport Support Systems" (ARTS, 2011-15, www.cost-arts.org) currently comprising of staff from c.60 establishments in 24 European countries. This unites transportation engineers, computer scientists and road traffic stakeholders with the aim of creating self-managing road networks. McCluskey is also leader of one of the projects within the £16M EPSRC-Industry supported Autonomous Intelligent Systems programme, "Machine Learning and Adaptation of Domain Models to Support Real Time Planning in

Autonomous Systems" (Hedlamp, 2012-2016, www.aiai.ed.ac.uk/project/hedlamp/static/), with partners University of Edinburgh and Schlumberger Research Cambridge, with additional industrial financial and technical backing from BAE Systems, National Nuclear Laboratory, Sellafield Ltd, Network Rail, SCISYS, DSTL and the UK Space Agency.

- **Grigoris Antoniou** was Activity Leader (Research) in the PlanetData European Network of Excellence on semantic data management (2012), he was principal researcher and FORTH node coordinator in the APARSEN Network of Excellence on digital preservation. He maintains a number of close collaborations around the globe, including Australia, where he is Adjunct Professor at Griffith University and Partner Investigator in two ARC Discovery Grants. In his EU-funded project PRELIDA he works with CNR (Italy), STI Innsbruck (Austria), APA (Netherlands) and Europeana on preserving linked data. In the recently started Marie Curie International Research Staff Exchange project SemData he works with leading research groups around the globe (among them from Stanford and CSIRO) on advanced management of semantic (linked) data.

- **Wolfgang Faber** was the local coordinator in the Italian PRIN project "Nonmonotonic Description Logics: Complexity and Implementation" (2010-2012) with partners based in Naples, Turin, and Pisa, and was a key investigator in the Italian PIA project "DLVSYSTEM" (2008-2012) on extending, optimising, and deploying an Answer Set Programming System. He frequently collaborates with researchers at the Vienna University of Technology, Austria, and the University of Calabria (being adjunct faculty at both universities), also having been part of a bilateral Italian-Austrian internationalisation project (2004-2008). Other regular collaborators are Prof. Truszczynski of the University of Kentucky, USA, Prof. Subrahmanian of the University of Maryland, USA, and Prof. Dix of the University of Clausthal, Germany.

- **Joan Lu** is Guest Professor for the School of Software (one of 35 key state software schools), Yunnan University, China, and Faculty of Computing and Information Engineering, Shaanxi University of Science and Technology, China. She was PI at Huddersfield in three projects within The Leonardo da Vinci Programme of the EU's Life-long Learning Projects: Edumecca, DO-IT, and DONE-IT (2008-2012, project nos. 143545-LLP-NO-KA3-KA3MP; 2009-1-NO1-LEO05-01046, and 511485-LLP-1-2010-NO-KA3-KA3MP). Within an interdisciplinary team of 7 partners, these projects researched and developed the "student response system" (SRS) platform for mobile devices in the field of vocational education and training. The SRS has been disseminated and demonstrated in international conferences, workshops, companies, schools, universities, including a demonstration for iPod and iPhone in the world largest's International Conference (with about 2000 attendees) on Technology Supported Learning and Training EDUCA 2009, Berlin, Germany, December 3, 2009 http://digitaljournal.com/article/282246. SRS was one of the five projects invited by the EU to be demonstrated at its stand in Berlin http://www.jfernandoferreira.com/mgse/oeb/programme_detail_31-34.html?id=t9.

- **Zhijie Xu** is Guest Professor at the Xian University of Science and Technology (XUST) and Xian University of Post and Telecommunications (XUPT).

- **Di Cai** has a Visiting Scholarship (as a Distinguished Foreign Expert in data analysis) at Beijing Institute of Technology (BIT), pursuing research collaboration with Professor Rong Pei (2011-2016).

Contribution to the discipline or research base:

Group A: PARK

- **Grigoris Antoniou** is on the Editorial board membership of Knowledge and Information Systems (2010 -); Editor of Journal of Artificial Intelligence Tools (2010-), Guest editor, Journal of Web Semantics, Special Issue on Semantic Web Dynamics (2010), Guest editor,

Journal of Logic and Computation, Special Issue on Ontology Dynamics (2009). He has made Keynote address at ICTERI 2012, at RuleML 2011, and at ADBIS 2010. He is an ECCAI Fellow and BCS Fellow. He is Member, European Coordinating Committee for Artificial Intelligence (ECCAI) Board, Treasurer, Semantic Technologies International (STI2). He was general Co-Chair, RuleML 2012: General Chair, 8th Extended Semantic Web Conference (ESWC'2011), PC Co-Chair, 7th Extended Semantic Web Conference (ESWC'2010),: PC Co-Chair, 2009 IEEE International Conference on e-Business Engineering (ICEBE 2009), Macau, China. He was: Activity Leader for Research, PlanetData Network of Excellence (EU FP7 project)

- **Lee McCluskey** has pioneered the area of Knowledge Engineering for AI Planning (KEPS), having co-organised Knowledge Engineering for AI Planning workshops or competitions each year 2008-13 at ICAPS, and co-edited two special issues of the Knowledge Engineering Review: Special issue on Planning and Scheduling Vol 25 issue 2, (2010), and Special issue on Knowledge Engineering for AI Planning, Volume 28, issue 2 (2013). In 2012, he was programme co-chair of the 22nd International Conference on Automated Planning and Scheduling (ICAPS), with Prof Brian Williams of MIT, held at Sao Paulo, Brazil. He served on the ICAPS council for a 6 year term 2006-12, acting as competition liason and hence having oversight of the global ICAPS IPC and ICKEPS competitions. He was elected Fellow of the BCS (2011), and is currently an EPSRC College member.

- **Wolfgang Faber** is on the Editorial Board of the Journal of Artificial Intelligence Research, ISSN 1076-9757 (7/2012-6/2015), the Editorial Board of Advances in Artificial Intelligence, ISSN 1687-7470 (9/2011-), the Editorial Board of Conference Papers in Computer Science, ISSN 2314-5919 (10/2012-), and the Editorial Board of The Scientific World Journal, ISSN 1537-744X (10/2013-). He was Guest Editor of Theory and Practice of Logic Programming (ISSN 1471-0684), vol. 13 special issue 02 "25th Annual GULP Conference", and is Guest Editor of Semantic Web – Interoperability, Usability, Applicability (ISSN 1570-0844), special issue "Web Reasoning and Rule Systems". He delivered keynote addresses at the 5th Workshop on Answer Set Programming and Other Computing Paradigms, Budapest, Hungary (9/2012) and at the 23rd Italian Conference on Computational Logic, Perugia, Italy (7/2008). He was programme co-chair (with James Delgrande of Simon Fraser University, Canada) of the International Conference on Logic Programming and Nonmonotonic Reasoning 2011, Vancouver, Canada, programme co-chair (with Domenico Lembo of Sapienza University of Rome) of the International Conference on Web Reasoning and Rule Systems 2013, Mannheim, Germany, co-chair (with Nicola Leone of the University of Calabria) of the Italian Conference on Computational Logic 2010, Rende, Italy, co-chair (with Joohyung Lee of Arizona State University) of the Workshop on Answer Set Programming and Other Computing Paradigms 2008, Udine, Italy, and 2009, Pasadena, USA.

- **Patrick Doherty** was elected president of ECCAI, the European Coordinating Committee for Artificial Intelligence, in August 2012. He gave an Invited Keynote talk at the 2012 European Conference on Artificial Intelligence (ECAI 2012) entitled "Leveraging KR Techniques in Autonomous Unmanned Aircraft Systems" and was co-editor of the related volume "Frontiers in Artificial Intelligence" volume, 2012. He gave an invited talk at the Second International Symposium on Practical Cognitive Agents and Robots at Sydney, Australia, 2008.

- **Mauro Vallati** co-developed PbP, the planning system which was awarded the *winner of the learning track of the 6th International Planning Competition* (IPC-6), at ICAPS 2008, and also PbP2, an improved and enhanced version of PbP, which was awarded as the *winner of the learning track of the 7th International Planning Competition* (IPC-7), in ICAPS 2011.

- **Lukas Chrpa (**with Mauro Vallati and Lee McCluskey) is organising the deterministic track of the 2014 International Planning Competition to be held at ICAPS 2014.

- **Andrew Crampton** was co-chair of the 29th Workshop of the UK Planning and Scheduling Special Interest Group (with Lee McCluskey and Diane Kitchin of the Informatics Department), which was staged at Huddersfield in December 2011.

Group B: VIV

- **Zhijie Xu** was Co-Chair of the 17th International Conference on Automation and Computing (ICAC'11); he is on the editorial board membership of the Journal of Internet Manufacturing and Services; he is editor of the Special Issue on Virtual Reality and Virtual Environments in the International Journal of Automation and Computing.

- **David Peebles** was co-chair of COGSCI 2012, the 34th Annual Meeting of the Cognitive Science Society, Sapporo, Japan, 2012 and co-chair of the ICCM2009 conference in Manchester. He has edited two special editions of the journal Cognitive Systems Research and is editor of AISBQ, the quarterly publication of the Society for the Study of Artificial Intelligence and Simulation of Behaviour (AISB). He is also Review Editor for the journal Frontiers in Cognitive Science and on the editorial board of the journal Computational Cognitive Science. David is a committee member of AISB and on the steering committee of the International Conference on Cognitive Modeling (ICCM).

- **Devina Ramduny-Ellis** was the co-Organiser and co-Chair of Physicality 2012, Fourth International Workshop on Physicality, in conjunction with BCS HCI 2012 conference, University of Birmingham, September 2012. She co-edited a Special Issue on Physicality and Interaction for Interacting with Computers Journal in 2009. She was also the co-Organiser and co-Chair of Physicality 2009, Third International Workshop on Physicality, in conjunction with BCS HCI 2009 conference, at the University of Cambridge, September 2009.

Group C: ISE

- **Joan Lu** Joan Lu is Editor in Chief for The International Journal of Informational Retrieval Research, Editor / Associate Editor for the ICOMP conference series (2003 - 2011), Associate Editor for IKE'13 and IPCV'13 conferences. She was journal issue editor for The Open Information Systems Journal, 2009; The Open Information Science Journal, 2009; and the International Journal of Informational retrieval Research, 2011. She is an Editorial Board Member of the International Journal of Research and Reviews in Information Sciences (IJRRIS), Science Academy Publisher, UK. She was the Chair and founder of the international workshop on XML technology and applications (2003-2011), and was General Chair for The International Conference on Education & Learning in Mobile Age – CELMA11, June 2011, UK, and for Computer Networks and Future Internet Symposium 2012, 4th International Conference on Communications, Mobility, and Computing (CMC 2012). She was guest speaker for HEA STEM (Computing): 2012, Buckingham, UK http://www.heacademy.ac.uk/events/detail/2012/15_May_HEA_STEM_App_Dev_Buckingh am. She received an Outstanding Service Award from IEEE ScalCom in 2010.

- **Vassilis Christophides** is a past recipient of the ACM/SIGMOD Test of Time Award, and an Editor of the International Journal on Semantic Web and Information Systems (IJSWIS). He was Chair of the 8th Extended Semantic Web Conference (ESWC'11) Semantic Data Management Track and Program Vice-Chair of the 7th International Semantic Web Conference (ISWC 2008). He has a sustained track record of participation in EU-funded research projects, including DIACHRON, HYDROBIONETS, APARSEN, KP-Lab, CASPAR and DELOS.