Institution: Edge Hill University

Unit of Assessment: 11 - Computer Science and Informatics

a. Overview

The Department of Computing was established as an independent unit in 2012, and it has already seen significant investment in people and infrastructure. This is its first REF submission. Since achieving research-degree awarding powers in 2008, the University's strategy has placed a far greater emphasis on research. In the case of Computing this emphasis translates into key areas which have now developed into research groups: Data Analysis and Representation (DAR), Distributed and Creative Technologies (DisCreat) and Computer Assisted Teaching and Learning (CATL). Five members of staff are returned here, **Anderson, Balakrishna, Hall, Mustafa, Pereira,** and their research is complemented by a research assistant, five full-time PhD students, and two Honorary Research Fellows. One colleague (Beaumont, HoD), is returned to the Education panel. Research planning is overseen by the director of research (**Pereira**) and discussed by the departmental research committee which she chairs. This committee discusses and approves departmental research strategy and helps to monitor progress. It is also responsible for ensuring that the department is compliant with the governance framework of the University for its research and knowledge exchange activities.

b. Research strategy

Although there was no return to the RAE in 2008, the department has planned its research with the goal of generating excellent research that would be eligible for a submission to the REF 2014. The emphasis has therefore been on building research capacity, and this emphasis will continue over the next five years. The strategy has been to establish a clear research profile for the unit which would have 'real world' application and encourage close links with research users and external collaborators. To that end, we identified three core areas of expertise represented by the research groups and established six target areas for development.

i. The first priority has been the production of high-quality research and to allow time for this to be realised. To do this we have changed the workload model to put greater emphasis on time for research. Staff are required to identify objectives in their Annual Academic Return and this is monitored annually by the Head of Department, Dean of Faculty and the Director of the Research and Enterprise Support Office (RESO) to ensure that personal goals are achieved.

ii. Alongside support for existing members of staff with established or emerging research profiles, the recruitment strategy has also shifted to give greater focus to demonstrable research ability, with research interests complementary to our profile (**Hall, Balakrishna**). Early career researchers (ECRs) are supported in their new role by having reduced teaching and administrative responsibilities.

iii. A third strand of the strategy has been to develop our post-graduate research community. We have done this in two ways: firstly we have established an MRes in Computing to support students in developing research skills in preparation for a PhD and secondly, we have recruited PhD students through fee waivers and the Faculty's Graduate Trainee Assistant (GTA) programme (established in 2012); this has resulted in increased PhD student numbers from one PT to five FT students.

iv. Fourthly, we have supported knowledge exchange by encouraging attendance at conferences and workshops, and invested in enhancing the research culture by organising regular research events for all staff, graduate students and fellows to encourage networking with partners and business. Our links with external organisations both academic and non-academic have grown and now include the US Air Force, UK Met Office, and the NHS, both as collaborators and research users and beneficiaries.

v. Fifthly, the University has invested in equipment to ensure that researchers are able to realise their objectives. £18m has been invested in the new Creative Edge Building, which now houses the Department of Computing. This has involved the provision of additional computer laboratories and the acquiring of specialised equipment such as high performance computer cluster, robots, mobile devices and microcontroller kits.

vi. Finally, it has been our goal to generate external income to support research. To realise this we have focused initially on small to medium-sized external grants, such as JISC, HEA, KTP and others, including funds from commercial sources, in order to establish a profile. The department's Enterprise Team supports researchers in making bids. The intention is to secure

a sustainable research culture on the basis of which to expand, with a view to bidding for larger grants in the next REF cycle.

In the census period, the establishment of the three research groups has brought together researchers with similar interests to generate projects alongside graduate students, staff not included in this submission but whose work nonetheless is maturing (**Coleman, Gavan, Liptrott**) and external collaborators. All these projects push forward our strategy of generating collaborations with external partners, both academic and commercial, and address issues that are directly connected to the needs of our research users.

The ***Data Analysis and Representation*** (DAR) group (**Anderson, Hall** + GTA (Owens)) consists of themed strands of research in the fields of (a) Software Quality Assurance, (b) 3D Visualisation and (c) Mobile Data Representation. Two of the strands are driven by international collaborations with partners based in the UK, USA and Canada and supported by external sources of funding. The third strand of research is driven by a large project with UK-based partners, and work is under way to develop a substantial funding bid to support the on-going work. In brief:

a) The outcome of one of the ongoing projects is directly relevant to any organisation developing large software models particularly in the fields of science and engineering where Fortran continues to be the predominant language used. Further work within the group is directed towards the development of software tools which will assist with the automation and visualisation of relative differences between the output of such software models, such as that led by **Anderson** to assist and improve the management of wetstock in petro-chemical installations;

b) The team, in collaboration with Brock University in Canada, is developing software that will allow historians to create three dimensional representations of historical buildings. The outcome of this project, the HistorySpaces, will become an on-line portal capable of supporting the representation and distribution of multiple virtual worlds devoted to historical topics. It will emphasize two domains of history: architectural or urban history, which it will support through the representation of historic structures, and social history, which it will support through the geo-visualization of attribute data.

c) The Mobile Data Representation strand of the research is focused on a collaboration between the Department of Computing and National Museums Liverpool, developing a virtual environment in which visitors to the City of Liverpool can explore the historical events and buildings which have shaped the growth of the city. Further work within this strand of the group's activities is exploring the representation of DNA data through an audio/visual representation which will be determined using geo-location data.

Maintaining the focus on the needs of research users, the members of ***DisCreat*** research group (**Pereira, Mustafa, Balakrishna** + PhD students**,** Akinbi, Campbell and Hearty) focus on finding theoretical advances and practical solutions in three important areas of Distributed Technology and e-activity: (a) Assistive technology, (b) Distributed/Mobile systems, (c) Multimedia Networks.

a) As part of our strategy to develop an income and to work with collaborators and research users, KTP monies were secured for the project on Assistive Technology led by **Mustafa.** This is delivering behaviour-pattern based software that will contribute to local-authority planning for assistive support and will also provide better assessment of the requirements of monitoring products for supported independent living.

b) Fulfilling the agenda of future "Smart Cities", **Pereira** and **Balakrishna** are working on utilising distributed and mobile and sensor technology for delivering improved services for citizens' convenience. Building on her expertise in the area of next-generation networks and architectures **Balakrishna** is working on using sensor and mobile technologies to develop applications for smart cities with **Pereira** contributing to understanding and utilising modern paradigms such as SOA, autonomic and cloud computing. The most recent project is looking at developing a cloud-based platform that will enable healthcare providers to develop applications that can run on mobile devices and assist them in patient care, monitoring and education.

c) A further collaboration is evident in **Pereira's** work with academics from Liverpool John Moores University (LJMU) on experimenting and defining requirements for real time video streaming. Results show that using a novel method for smoothing video packets significantly improves video streaming as a real time application. The next step in this project is to evaluate modern methods of streaming, such as used by YouTube and Netflix, particularly in the context of mobile devices. This research may have very high impact within the Creative Industries on millions of

people who daily view videos using mobile devices. With the contribution of a newly-recruited staff member **Balakrishna** in next-generation multimedia networks this project aims to move from a simulation-based stage onto real-life test based development.

The main aim of the third group, **Computer Assisted Teaching and Learning (Mustafa,** Beaumont, Gavan, Moscrop, Canning and Hunter-Barnett), is to evaluate the impact of existing technology on teaching and learning such as digital audio feedback, problem-based learning in second life, online PBL, and others. **Mustafa**, whose research interests include pedagogical aspects of educational systems, has developed and widely disseminated the CPU-OS Simulator for teaching and learning purposes. This software makes use of visualisation techniques and assists students in learning core subjects of computing such as operating systems, compilers and computer architecture. There are other similar types of simulators on offer; however, having extensive and tightly integrated interactive, visualization, animation and pedagogical features make this tool novel in that it offers much more than other existing tools. It has attracted interest worldwide and has been adopted and evaluated in different colleges and universities in over ten countries.

With the research groups now firmly established, our future strategy is to build on these foundations, in order to be recognised at national and international levels for excellence, specifically in data analysis and visualisation, mobile and assistive technologies for healthcare, and creative technologies. Our priority remains to grow the number of research-active staff who will reach the standards for inclusion in REF2020. This will be achieved by including more staff in the research groups where they can be mentored by more experienced staff and generate their own research projects within the themes. We are aiming to recruit our first professor and to appoint visiting professors for each of the research groups, who will also act as mentors for both staff named in this submission and newly emerging research-active staff. This approach will be complemented by the recruitment strategy which will continue to foreground research.

Alongside the growth in research active staff, our focus will also be to achieve the successful completion of the doctorates currently being undertaken by our PGRs and the recruitment of more students. PGR recruitment will focus on projects that fit with the work of the groups to ensure that the students get the maximum benefit from their PhD studies. During this process we will be developing our supervisory capacity but should additional expertise be required, external appointments to the supervisory teams will be made. A vibrant PGR community is central to any dynamic research environment and is essential to provide peer support for the students. The faculty has established a GTA programme which provides a comprehensive 3-year package of support for twelve students per cohort: this strategic initiative to grow PGR numbers in the faculty began in September 2012 and is to continue for five years at least. The department competes with other areas in the faculty to win GTAs and to date has been very successful. In addition to the GTA scheme, we shall also be looking to secure funds from external sources to provide studentships.

Generating more research income will be achieved by targeting a broad array of funders including our commercial partners and the main research funders, alongside those where we have a track record. A key element of generating research will be to establish effective partnerships with other HEIs where we will submit bids as co-investigator to help develop staff expertise in bid writing and to establish a track record in successful delivery of funded projects. Additional support for bid writing comes from University mechanisms such as recently established Peer Review College and the programme of training workshops organised by the University's Research & Enterprise Support Office (RESO). Information about opportunities is coordinated by the Director of Research (DoR) who ensures that these are disseminated effectively. The DoR liaises closely with the RESO to ensure that it is familiar with the research and can direct suitable funding opportunities to staff. To continue to foster the development of research which focuses on practical solutions to problems and challenges within computing and information systems, the department will build its relationships with non-academic communities. Having worked successfully with a number of partners, such as the US Airforce, Simcom, local firms (e.g., Fairbanks in Skelmersdale, Business Insight 3 LLP, Preston), local councils, museums, schools, the NHS, care homes and IT organisations, we will be looking to deliver research-informed solutions to them regionally, nationally and internationally and to new partners.

c. People, including:

i. Staffing strategy and staff development

Edge Hill University is committed to supporting people in developing as researchers and is fully committed to equal opportunities in both its recruitment process and its training and development for research staff. The central ethos of the staffing strategy is to support staff to reach their full

potential by appointing the best staff for the role and in supporting them to achieve. Research is central element of the recruitment and progression process. Excellent research is recognised by the promotion to reader (**Anderson, Pereira**) and a proven track record in research is a central criteria on appointments (**Balakrishna, Hall**). All new appointments must also bring expertise which will enhance our profiles for example, **Balakrishna** and **Hall** have brought important skills and expertise for further development of strategic areas such as mobile technology, next-generation multimedia networks, and data analysis and visualisation. To augment research leadership the department will appoint its first chair and will recruit visiting professors and honorary research fellows in the research groups: honorary appointments are for up to two years and contribute additional expertise and experience.

The University and department are aware of their responsibilities to promote equality and diversity among the staff complement. The University is preparing an application for an Athena Swan Bronze award and while this Computing return is a small submission, it is worth noting that one of the department's two readers is female and she is also DoR (**Pereira**). **Balakrishna** is a recently-appointed early career researcher. Therefore female academics make up 40% of this submission. Nevertheless, we are exploring support, such as Vitae's Leadership in Action programme, to encourage women to aspire to leadership roles.

The Department's strategy supports the academic staff in their research requiring annual research plans as part of the Annual Academic Return. This offers staff the opportunity to report on research and knowledge exchange activity over the previous year and to report on any changes from the stated plan. It also asks staff to identify their research training needs. In keeping with the University's obligations to the Concordat to Support the Career Development of Researchers, the University offers a comprehensive programme of training through its centrally-provided Research Capacity Building Programme (RCB). The RCB is explicitly mapped on to Vitae's Research Development Framework (RDF) with workshops designed to align with the RDF domains and guidance on how to access other support to address the areas identified in the RDF. All staff, regardless of contract, have access to the RCB. To maximise the potential of the RCB, staff members are encouraged to use the RDF planner to establish a needs analysis (the University is currently piloting the electronic version). The RCB includes sessions on bid writing, writing for publication, research planning, project management and a range of methodologies and data analysis techniques. Where needs cannot be met internally, staff are funded to attend external training events. In addition, there is a research mentoring database where individuals can search for professors and readers from across the institution with relevant experience to help them with their research projects and personal development. The University also supports staff with doctoral studies to enable them to develop research skills. This support includes a 50% contribution towards fees and funding to present at conferences. This approach has resulted in one member of staff recently completing part-time PhD studies at the University of Liverpool and another staff member expected to complete next year at Lancaster University. On completion of their PhDs staff are supported in generating a personal research plan to ensure that the PhD is converted into research outputs and that a continuation strategy is adopted for their post-doctoral research. This strategy should result in a significantly higher proportion of departmental staff being eligible for return in REF2020.

The University provides strategic funds to support research, the Research Investment Fund (RIF), which is complemented by faculty resources. The RIF prioritises new appointments and ECRs, although all staff are eligible to bid for conference travel grant, sabbaticals or for any other research related activities. Priority is also given to pump-priming projects which will be the basis for a bid for external funds. Computing group members have been successful in securing sabbatical leave, teaching relief and conference travelling grants from the RIF. This pump priming has led directly to the award of a KTP.

As well as being supported by the RIF, ECRs are also encouraged to join supervisory panels with more experienced members of staff to gain experience of PhD supervision. There is also training for staff new to supervision. ECRs are also given opportunities to participate in faculty committees to provide them with career development opportunities and to gain an understanding of the broader research context of the institution. All new staff have a departmental and institutional induction which includes a session on research management and administration.

ii. Research students

Being relatively small, the Department of Computing can supervise a limited number of research

students. Nevertheless we have seen considerable growth in student numbers. In the census period, one PhD and one MPhil have been awarded to computing research students under Lancaster accreditation. Following the increase in the number of experienced PhD supervisors, there are currently five full-time PhD students. There are supervisory teams set up for each student with at least one member having supervised a PhD to successful completion. The progress of the research students is closely monitored by the director of studies and also by the Graduate School. Each student and their director of studies submit Annual Progress Reports which are reviewed by the Graduate School Board of Studies. Students undergo *viva voce* examinations with external academics at the transfer from MPhil to PhD as part of their personal development towards the final *viva.* All PGRs receive generic skills training organised by Graduate School in their first year and are encouraged to attend the RCB sessions to complement this throughout their registration. Some of the generic training takes place at weekend residentials which helps generate cohort identity and peer group support while the University as a whole is developing its PGR numbers. Departments are responsible for discipline-specific training. Students are required to complete the RDF training needs assessment annually to plan their training with their supervisors. As part of their professional development, all PGRs are required to present at research group seminar series each year and are encouraged to attend external conferences to gain experience and to network.

Funds are made available to support students in carrying out their research from both the department and via the competitive Graduate Bursaries. These funds can support students to undertake external training, attend conferences, and conduct research and field trips. The GTA programme provides students with the opportunity to gain teaching experience and this is supported by training on the PGCert in Learning and Teaching. Non-GTAs also have some teaching opportunities and access to the PGCert to support them to develop as academics.

The Department aims to increase the number of PGR students by utilising various mechanisms available internally and externally. In 2012, the Faculty introduced the new GTA scheme that offered fee-waiver studentship with paid teaching hours and free accommodation on campus. The department has benefited from this initiative and recruited three students under this scheme. This scheme is planned to continue for five years recruiting postgraduate researchers on an annual basis. Additionally, the RIF has supported full-time fee-waiver PhD studentship for a multidisciplinary project and research associate posts for the Quality Assurance for Climate Codes (QACC) project and the HistorySpace project.

Furthermore, the Department has for a number of years been successfully running a number of Masters programmes and has seen two MSc graduates progressing to PhD level. A new MRes in Computing has also been validated with a view that this programme will provide an alternative option to MPhil/PhD programme, as MRes graduates will be eligible to directly progress to the PhD studies. It is our long term aim to build links with north-west based universities to establish a DTA in Technologies for Smart Cities.

d. Income, infrastructure and facilities

The Department of Computing has recently moved into a purpose-built Creative Edge building providing six computer laboratories equipped with up to date software to cater for students and researchers. The laboratories are maintained by a technician. Two of these laboratories have up to date networking technology and others are equipped with general use hardware and software. All research-active staff have been supplied with the required technology to undertake their research e.g. networked PCs, Cloud or mobile technology set up in their offices. There is also a research-only laboratory used by research students/assistants and other research active staff for experimental and development work. The team is currently working on setting up a “living” lab which will contribute in advancing the assistive technology research project. In addition to this the university library provides access to many international journals and conference proceedings through electronic resources such as Emerald, Elsevier journals, IEEE Xplore and Springer.

The University is prioritising research and knowledge exchange activity through the establishment of three new research institutes (RIs), one of which is the Institute for Creative Enterprise (ICE) designed to bring together researchers from Media, Computing, the Business School, English, History and Performing Arts to foster collaborative, impact aware research projects between different disciplines. Computing has already identified areas, such as 3D modelling, data visualisation and multimedia content networks that will be contributing to the interdisciplinary research project led by the Institute. The new Creative Edge building also houses the Department of Media with its animation and recording studios. Sharing the building with Media opens a wide

range of opportunities for developing both interdisciplinary programmes and research. A second RI, the Post-Graduate Medical Institute (PGMI), brings together researchers from across the University in health and well-being and has close links with the NHS trusts and hospitals in the region. **Mustafa** and **Pereira's** work on e-health and assistive technology is part of Prevention and Detection, the public health, diagnostics and medical technologies research themes of the PGMI.

The Department of Computing has Departmental Research (DRC) and Research Ethics committees (DREC) both chaired by the Director of Research. The DRC includes the HoD as a member and is responsible for developing and monitoring research strategy. The DREC ensures that all research projects, when necessary including undergraduate and postgraduate projects, have appropriate ethics clearance. Both committees report to Faculty Research Committee (FRC) and Faculty Research Ethics Committee (FREC). The FRC, with representatives from each department, coordinates activities such as bidding process, postgraduate studentships, collaborations between departments and other strategic issues and reports to the University Research Committee which also has departmental representatives. The University's research governance is overseen by the University Research Ethics Committee (UREC) which has representation from each faculty. UREC oversees the activities of the FRECs to ensure that all research is carried out in an ethical manner. The Code of Practice for the Conduct of Research and the Code of Practice for the Reporting of Research Misconduct are compliant with the Concordat for Research Integrity.

The Department has implemented a bottom-up strategy that has allowed us to develop a track record of wining small external grants. In 2008 **Mustafa** received £2746 from Higher Education Academy (HEA) that enabled him to evaluate his CPU/OS simulator on a larger scale. Beaumont (HoD) has been successful in gaining external funding totalling £26,000 for a number of projects from JISC. This approach has also helped in building grant writing skill sets within the team. This was evidenced in winning three medium size KTP grants: £38,000 in 2010 (**Mustafa**), £67,000 in 2013 (**Anderson**) and £115,000 also in 2013 (**Anderson**). **Anderson** was also successful in obtaining £14,000 from the US Air Force and £10,000 from Brock University. A departmental Enterprise Team assists in identifying opportunities for collaborative and commissioned research, yielding 20 projects in the last two years. The University's new Consultancy Policy allows a high proportion of net fee income from consultancy to be retained in the department to support research, including supporting PhD students.

In addition, the University's internal research funding has also been utilised for a range of research related activities. In the last few years, over £30,000 was invested in building profiles, enhancing the research environment of the unit, pump priming research projects and strengthening external collaborations and partnerships: the UCAR relationship (see below) has been supported from central University funds. In the medium term, the unit will focus its strategy on developing collaborations with external partners; promoting interdisciplinarity; emphasising smart specialisation on key strengths identified here; building long term relationships with funders; and by having a flexible approach to intellectual property. The longer term strategy for income generation will focus on encouraging and supporting experienced staff in submitting grant applications to major funding bodies such as in the RCUK. At the same time, ECRs and less experienced staff will be encouraged to join collaborative bids, both internal and external, as co-investigator. Particular importance will be given to the upcoming EU funding programme Horizon 2020. Our strong links with industry partners and experience of participating in industry funded projects places us in a strong position for competing for Horizon 2020 which fosters strong collaborations between academia and industry.

e. Collaboration or contribution to the discipline or research base

As part of our growing research agenda we have emphasised the importance of collaborative and interdisciplinary research. At the internal level, our collaboration with other units of the University, extends beyond the Faculty of Arts and Sciences. We have formed strong collaborations with the Faculty of Health and Social Care and the Faculty of Education. Those staff members working on data representation and 3D modelling (**Anderson, Hall**) are working in collaboration with other University colleagues under the aegis of the Institute for Creative Enterprise (ICE). The collaborative projects at the regional level include developing high performance and improved security network solutions and efficient data storage for Merseyside SME Fairbanks, and developing solutions for management and monitoring of data being automatically generated from remote sensing devices which detect leakage of wetstock from storage units in collaboration with a petro-chemical storage monitoring company based in the region. There are also ongoing projects with Liverpool World

Museum to bring enhanced visualisation and interaction to the exhibits with a goal of engaging the public using bespoke multimedia artefacts and gesture-based user interaction devices.

National academic collaborations that group members have been engaged with recently developed a greater international dimension by developing strong links with US-based agencies and Canadian universities. **Anderson**'s work in collaboration with SimCon Ltd and the University Corporation for Atmospheric Research (UCAR) based in Boulder, Colorado aims to make the University a centre of expertise that can offer a valuable service to climate change research groups across the world. The project team are currently working with the UK Meteorological Office and Fujitsu USA to assist in the porting of software to a supercomputer architecture.

Computing staff's engagement with the wider community and their contribution to the discipline is further demonstrated in the following list of selected indicators:

Anderson

- PC member of
  - IEEE ICITST, Abu Dhabi, 2011
  - 2nd/3rd International Conference on Educational and Information Technology (ICEIT 2013 and ICEIT 2014) in Hong Kong (2013) and Canada (2014), organized by IACSIT
  - the 5th International Conference on Computer Engineering and Technology (ICCET 2013),Vancouver, Canada, 2013

Balakrishna

- Invited Keynote at "Apps for Smart Cities Conference", a World Smart Capital Initiative, Amsterdam, 29th March 2012.
- Invited Presentation on Open Source Technologies for Next-generation Networks at First International Workshop on Next-Generation Networks: Open Platforms and Systems, 16th September 2008, Cardiff, UK
- Founder and Chair
  - International Workshop on Technologies and Applications for Smart Cities. I-TASC'12 (Paris), I-TASC-13 (Prague).
  - IEEE International Workshop on Next-Generation Networks [NGNOPS]
  - IEEE NGMAST

Hall

- PC member of
  - SUEDL workshop 2012, 2013
  - WWW conference 2012, 2013, 2014
- Co-Organiser of
  - TREC Session track 2011, 2012, 2013, 2014
  - CLEF CHiC Interactive track 2013

Mustafa

- Invited Keynote at the International Conference on Communication, Media and Technology, in Istanbul, Turkey, May 12 - 14, 2012.
- PC member of FISER'09 (Frontiers of Science Education Research)

Pereira

- Founder and co-chair of IEEE ICITST CAS since 2010 to date.
- PC member of
  - IEEE ICITST, IEEE AINA, IEEE ITST, IEEE ICC WS – MobiCHeSS , IEEE ICCVE 27th UKPEW, Bradford, July, 2011

The department has hosted and provided a supportive environment for visiting academics from the School of Electronics and Information Engineering, Changsha Social Work College, China; Bucharest Academy of Economic Studies, Romania; Brock University, Canada and University Corporation for Atmospheric Research in Boulder, US, as part of a strategy to develop international research links and broaden our horizons.