Institution: Leeds Metropolitan University

Unit of Assessment: UoA11 – Computer Science and Informatics

Title of case study: Green IT

1. Summary of the impact

The work of the Green IT research group has made significant contribution to the national agenda and within the EU's e-science research community. We provided an independent, measurement based assessment for Cisco of their energy management system and measured the energy demand of client-server systems and data centre improvements for JISC. This is of significance as "Green management" of large data centres is of critical importance for providers and users alike. Our work also contributed to measurement (and education about measurement) in the EU e-Science research community and provided capacity building via EU postgraduate Green IT development. We co-authored the University's Green IT strategy bringing about positive economic and environmental impacts locally which have then been used as exemplars by others.

2. Underpinning research

Professor Colin Pattinson was a founder member of Nortel's Technical Solutions Academy and has carried out funded research on behalf of Cisco, JANET (UK) and JISC. His research activity began with measurements of the performance of computer communications protocols. This formed the basis of research into network management tools and techniques, and the measurement focus has continued with measurements to identify energy use and efficiency. He developed a simulation for the exploration of network behaviour for trainee managers of computer communications networks (http://dx.doi.org/10.1006/jnca.2000.0104). The simulation generates network management information in patterns which mimic the behaviour of real network devices; these are then presented to users in a controlled manner through a network management interface via the Simple Network Management Protocol (SNMP, Reference r1). Making modifications to this information allows fault situations to be represented through SNMP data, and permits users to diagnose the fault from the information provided through SNMP as if they are managing an actual network. He continues to investigate the behaviour of SNMP over local and wide area networks (http://proceedings.utwente.nl/26/1/S9-2.pdf) and to explore the use of mobile agents to alleviate loads created by network management protocols and operations (Reference r2). Our expertise in IT network management systems meant that we were approached by Cisco Systems Ltd to carry out an independent assessment of the Return on Investment (RoI) for their EnergyWise network management product. Assessments and evaluations carried out at Brunel University, combined with desk research and extrapolations have been used by Cisco to provide product information relating to this product. Results of the case study and details of the impact are discussed in Section 4 and corroboration (i1).

The Leeds Met Green IT research group is led by Professor Pattinson and comprises both academics and practitioners. This history of work in measurement and management has enabled a development of the group's research focus to green or sustainability issues in IT. Some of the recent research work includes the development of a framework for reduced energy consumption and carbon footprints for organisations that are moving towards embracing Green IT (r6). Pattinson and Cross are conducting research into the energy consumption of thin-client technology (r2 and r5) which is supported by grant g2. This research entails rigorous experimental analysis providing real data relating to the comparative costs of running thin and thick client systems in a typical university environment. Pattinson, Warner, and Cross are conducting research on data energy efficiency (r3) which is supported by g4. This research explores various metering approaches (or topology) and monitors the power consumption in different parts of a data centre. It also involves the following: web-enabled monitoring system; data centre efficiency measurements and metrics and the use of analysed real data to drive improvements in data centre efficiency. This research work is being extended by a recently appointed PhD student who is developing an intelligent system to monitor and control energy consumption in a data centre. The details of our Green IT research impact are discussed in Section 4 and corroboration of the impacts is found in i2, i3 to i8. The emergence of this research area led to the development of the first "Green Computing" MSc award in the UK; and to working within the University to deliver more energy and resource efficient ICT facilities, including co-authoring the University's Green IT strategy **(**details of the strategy are

here: http://www.eventlink.org.uk/uploads/DOCS2/53-LMU_Salix_Presentation.ppt)

3. References to the research

(r1). Pattinson, C. (2001). A Study of the Behaviour of the Simple Network Management Protocol, Proceedings of the 12th International Workshop on Distributed Systems, DSOM, Nancy, France, October 15-17, 2001, pp. 305-314, ISBN 2-7261-1190-4, (cited by 27)
(r2). Pattinson, C., and Cross, R. (2011). Does "thin client" mean "energy efficient"? JISC Green IT Technical Report JISC Technical Report March 2011. ISBN: 978-1-907240-34-8 http://www.jisc.ac.uk/media/documents/programmes/greeningict/finalreports/ThinCFinalReport.pdf
(r3). Pattinson, C., and Cross, R. (2013). Measuring Data Centre Efficiency, JISC Green IT Technical Report January 2013. ISBN: 978-1-907240-33-1 http://repository.leedsmet.ac.uk/main/view_record.php?identifier=8250&SearchGroup=research
(r4). Forbacha, S., Pattinson, C. (2011). Simulation of Energy-Aware Mobile Agent Based Network Management System, Modelling Symposium (AMS), 2011 Fifth Asia, Issue Date: 24-26 May 2011, On page(s): 203 - 208 ;Location: Kuala Lumpur ;Print ISBN: 978-1-4577-0193-1 ;INSPEC Accession Number: 12137030 ;Digital Object Identifier:10.1109/AMS.2011.45
(r5). Pattinson, C., and Siddiqui, T. (2008). A Performance Evaluation of an Ultra-Thin Client System, Proceedings of Int. Conf. on E-Business and Telecommunication Networks – ICETE, pp. 5-11, ISBN: 978-989-8111-58-6.
(r6). Girish Bekaroo, Chandradeo Bokhoree and Colin Pattinson. (2013). Towards Green IT Organisations: A Framework for Energy Consumption and Reduction, International Journal of Technology, Knowledge and Society, Volume 8, Issue 3, pp.23-36, CGPublisher, http://ijt.cgpublisher.com/product/pub.42/prod.851

Grants

(g1). Cisco Systems (January 2009-January, 2010), £25,000, Energy Wise Assessment (review of Energy Wise energy monitoring software)
(g2). JISC (January 2010-December 2010), £50,000, Energy Use of Thin Client Technologies ("Does Thin Client Mean Energy Efficiency?")
(g3). JISC (February 2011-February 2012), £40,000, "Heat and Light by Timetable"
(g4). JISC (February 2011-October 2012), £50,000, "Measuring Data Centre's Efficiency"
(g5). JANET UK (Jan 2009-Jan 2010), £11,500 for development of low-cost, low-energy portable wireless LAN
(g6). HEIF (January 2009-January 2010), £40,000 for equipping a "mobile technology showcase" vehicle, including low energy IT support
(g7). HEA (August 2010-July 2011), £3200 for developing learning objects addressing sustainability
(g8). EU Erasmus Mundus (2012 - 5)–PERCCOM-€20K
(g9). EU TEMPUS (2012 - 5) – GreenCo – €63K
(g10). EU FP7 e-Infranet project (July – December 2013), project leader for development of educational programme (EISTER) – total funding €80K (€50K from e-Infranet partners, rest from individual participants).

4. Details of the impact

The impact of our Green IT research can be discussed in three strands: environmental/economic impact; Knowledge Transfer through sharing of technology and best practice; policies, awareness promotion, and transnational education provision.

1.Environmental/Economic Impact

***Cisco EnergyWise Assessment Consultancy Work*:** Our expertise in the measurement and assessment of IT network management systems (r1, r4 and r6) meant that we were approached by Cisco systems Ltd to carry out an independent assessment of the Return on Investment (ROI) for their EnergyWise network management product. Assessments and evaluations carried out at Brunel University, combined with desk research and extrapolations have been used by Cisco to provide product information relating to this product (i1).

***Green IT Strategy*:** Due to our 'hands on' approach to assessing the actual impacts of technology and process changes (r2, r3, r5 and r6), we have been able to make direct contributions to the development of our university Green IT Strategy, a strategy which has been cited as an exemplar by funding bodies (see below). We have made considerable savings (i2) implementing this strategy including replacement of desktop printers with intelligent "iPrint" devices with significant energy, paper, and toner savings; introducing new PCs which are more energy efficient and follow an Ultra

Small form factor; other PCs have been replaced with energy efficient thin-client ones thus resulting in considerable energy savings.; Desktop Power Management facility has been incorporated into all managed PCs.

Greening the Estates through ICT: In (r3) supported by g2, evaporative cooling systems are introduced. The results (in r3) show that the new evaporative cooling system seems to enhance energy efficiency. This research work is being extended using Salix Funding (secured by Warner). The first extension is installing an evaporative cooling system while retaining some air conditioning units for additional cooling requirements. The second is the installation of heating controls and new panel heaters within halls of residence. By promotion of the savings we are achieving within the University, we are seen as a leading force in this area as evidenced by the following quote from HEFCE's Salix Funding body: "Leeds Metropolitan University continues to successfully use their funding as part of their carbon management strategy. They committed 89% of available funds on heating and hot water controls, evaporative cooling and LED lamp replacement" (i2).

2. Knowledge Transfer through Sharing of Technology and Best Practice

Our work on data centre efficiency involves measuring, monitoring, and assessing the impact of certain parameter changes on energy consumption and the data center energy efficiency (r3). This research is funded by (g4) and it demonstrates how aggregated metering and monitoring via web-enabled facilities (gateways) could be done, as well as how energy efficiency metrics could be implemented in practice using real data (r3). We have shared the findings of this with a variety of audiences: technical, managerial and academic (i3). Many of the approaches we have adopted and reported upon are now common practice. While not claiming credit for originating these methods, we suggest that we have – at least – contributed to their adoption through our reporting.

The HEFCE document in (i4) offers guidance on carbon reduction strategies, targets and associated carbon management plans. Leeds Met has been cited as a case study for many carbon reduction areas for example: *"Quick wins are a useful way of maintaining staff and student enthusiasm for reducing carbon emissions. At Leeds Metropolitan University, quick wins included the introduction of air-handling fans with direct variable speed drive; sub-metering; and movement and light sensors – especially in gyms, toilets and lecture theatres. There are also a number of easily implementable IT solutions – including automatic overnight switch-off of equipment in IT labs"* (i4, page 17).

3. Policies/Standards, Awareness Promotion, and Transnational Education Provision

More recently we have contributed (through the BCS Green IT specialist group, i6) to the development of the Carbon Trust's "GHG Protocol Product Life Cycle Accounting and Reporting Standard ICT Sector Guidance", which is currently in final its drafting stage. We particularly highlight the need for the measurement processes mandated by this guidance to be more fully documented. We also contributed to an EU-supported e-infranet policy paper (i5). This policy paper addresses the environmental sustainability of e-infrastructures for science and research across European higher education and research communities and our particular contribution is on metrics and measurement for quantifying energy usage and performance.

We have also developed work which is having, or will have, impact on the current and future education and training of IT professionals (i7), our MSc in Green Computing was noted in IEEE's *IT professional* as one of only four such programmes worldwide (IT Pro March/April 2010, Published by the IEEE Computer Society). This expertise has led to participation in EU programmes developing research capacity in Green IT in Russia and Ukraine (g9), in a pan-European post-graduate research training and development programme (g8) and leading in creating a training programme for Data Centre managers on behalf of the e-Infranet project (g10) using the EU Data Centre Code of Conduct as its basis.

5. Sources to corroborate the impact

Environmental/Economic Impact

(i1) Cisco EnergyWise Assessment Consultancy Work (Case Study is Brunel University) http://www.cisco.com/cisco/web/UK/casestudies/assets/pdfs/Brunel_University_EW_Case_Study.pdf

(i2) Green IT Strategy to operationalise our corporate strategic plan relating to sustainability (http://www.leedsmet.ac.uk/strategicplan/Leeds-Metropolitan_Strategic-Plan_2010-2015.pdf). Details of the Green IT Strategy which is shared in a Salix Technical Workshop is here: http://www.eventlink.org.uk/uploads/DOCS2/53-LMU_Salix_Presentation.ppt

Knowledge Transfer: Sharing of technology and Best Practice

(i3) JISC Greening ICT Programme (Contact person is Rob Bristow, Programme Manager)

(i3.1) "Does thin client mean energy efficiency?" http://www.jisc.ac.uk/whatwedo/programmes/greeningict/technical/thinefficiency.aspx ;

(i3.2) "Measuring Data Centre Efficiency" http://www.jisc.ac.uk/whatwedo/programmes/greeningict/technical/datacentre.aspx .

Published by JISC in SusteIT News "A collaboration of several JISC-funded Green IT projects with metering cases" http://www.goodcampus.org/uploads/DOCS/133-SusteIT_News_June_2011.pdf

(i4) HEFCE (2010) – Carbon management strategies and plans: A guide to good practice https://www.hefce.ac.uk/media/hefce1/pubs/hefce/2010/1002/10_02.pdf

Policies, Awareness Promotion, and Transnational Education Provision

(i5) e-Infranet (http://e-infranet.eu/) – Green IT Network, "e-InfraNet Green Sustainability Policy Paper for e-Infrastructures", contribute to a policy paper which addresses the environmental sustainability of e-infrastructures for science and research across European higher education and research communities and our particular contribution is on metrics and measurement for quantifying energy usage and performance. http://e-infranet.eu/wp-content/uploads/2012/07/e-InfraNet-Green-Sustainability-Policy-Paper-1.02___1__BASIM.pdf

(i6) Professor Colin Pattinson is a BCS Green IT SG Committee Member: http://www.bcs.org/content/ConWebDoc/27291. This SG contributes to setting national standards for Green IT strategies (see http://www.bcs.org/upload/pdf/greenit-111209.pdf and http://www.bcs.org/category/10547) and also recommend that more measurements be included in the GHG Protocol "Product Life Cycle Accounting and Reporting Standard ICT Sector" Guidance http://www.ghgprotocol.org/feature/ghg-protocol-product-life-cycle-accounting-and-reporting-standard-ict-sector-guidance

(i7) Joint EU Green IT Postgraduate Provision (through e-infranet (http://www.surfnet.nl/Documents/IntroductoryCourseGreenDataCenter-1.pdf, and EISTER), PERCOMM (http://perccom.blog.univ-lorraine.fr/), GreenCo, http://my-greenco.eu/)