Beating the Paradox: Towards ICT-infrastructure that is 'Always On' and Green

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***Abstract*— User 'pull' for services coupled with 'push' from HM Government policy will lead to increased use of information and communication technology (ICT) infrastructure in everyday life. Today's *individual* ICT components are being built to be more energy efficient. However, in operational use, the lack of monitoring mechanisms for co-ordinating *system-wide* energy usage across distributed ICT infrastructures means that those ICT components may not be efficiently utilised. It is estimated that the ICT industry is similar to the aviation industry in CO_2 emissions, and its carbon footprint will triple by 2020. Addressing directly the disincentives to 'Green ICT', we will produce and make freely available software prototypes providing an *information model* and *monitoring application* to allow distributed ICT infrastructure to employ energy-aware system monitoring capability. This will enable monitoring, reduction and optimisation of energy usage, providing savings on energy costs. Reduced energy usage will also reduce CO_2 emissions. We will deploy and test our prototype system on the operational network of the University of St Andrews to demonstrate its utility. Our project output will enable the creation of new markets in energy-aware systems monitoring and management applications, from small-scale to large-scale systems.**

I. The 'pull' and the 'push' for 'Always On'

In the move to a knowledge-based, digital economy, there is increased use of ICT infrastructure. Users now wish to use ICT infrastructure in many aspects of their lives on a daily basis, for work and pleasure. Particularly, online services, where computer 'clouds' provide 'Always On' capability, are showing huge growth in the number of users, through applications such as online social networks (e.g. Facebook, LinkedIn), portal sites offering communications (e.g. Yahoo, MobileMe), as well as online document services (e.g. Google Docs, ThinkFree Office). Such services need to be 'Always On' in order to provide utility: indeed, the user perception is that these *are* utility services, and so *must* have high availability.

Meanwhile, Lord Carter's Interim Report, *Digital Britain* [1], outlines the formation of HM Government policy that would propose the increased delivery of public services through online systems. This would be supported by a *Universal Service Commitment* to the UK population for providing broadband services to every home, as well as improving mobile access through further availability of RF spectrum in the UK. Again, such public services provision needs to be 'Always On' to be effective.

A. The Green ICT Paradox

Clearly, high availability is paramount for such reliance on ICT services today and for the future. This is often implemented by using redundant systems resources to cope with variations in service load, as well as provision backup systems quickly to counter equipment and network failures.

It is often claimed that working online is more environmentally friendly than, say, driving to work in your own car. Recently, the European Commission has called on industry and member states to use ICT to improve energy efficiency[1]. However, recent reports indicate that there are high financial and environmental costs for ICT usage now and for the future:

- A report from the Renewable Energy Foundation (REF), predicts significant increases in electricity prices for the UK for the period 2008–2020 [2].
- An example. BT's role is mentioned in Lord Carter's report [1]. BT has stated publicly that it consumes around 0.7% of all electricity produced in the UK [3]. BT's concern about electricity supply and pricing has lead it to invest £250m on its own wind-power.
- A report from the Professional Association for Public Sector ICT Management states that, globally, ICT-related CO_2 emissions are similar to that of the aviation industry (2% of global emissions) [4].
- A report from the SMART2020 group (on behalf of the Global eSustainability Initiative[2] of The Climate Group[3]) predicts that the global carbon footprint of ICT will increase three-fold from 2002 to 2020 [5].

With demand increasing for usage of ICT, and ICT already acknowledged as a large energy consumer and large CO_2 producer, there has to be proactive and large-scale movement to reduce and optimise energy usage within ICT. However, a report from the UK National Computing Centre (NCC) summarises a survey and concludes that, of the 120 organisations surveyed, under 15% have a green IT policy and only 2.5% have established environmental targets or green key performance indicators (KPIs) [6].

B. Energy-aware ICT today

Many manufacturers are now producing individual equipment that is energy efficient. EnergyStar[4] compliant equipment has been available for some time, and many manufacturers now have proprietary energy saving mechanisms in ICT equipment. This is true for domestic equipment for homes and small business (e.g. desktop computers and monitors), as well as commercial equipment (e.g. servers, storage, network equipment).

However, equipment and services are used together to build large distributed systems and, today, there is no widespread, openly available *information model* that provides a common, administration-wide view of energy usage across an ICT infrastructure. So, while it is possible to purchase energy efficient equipment, full benefit may not be received by service providers and users because systems managers lack visibility of energy usage as part of a management system across their administrative domains. Indeed, the NCC report [6] states that server systems utilisation and power efficiency is typically "very

[1] EC calls for energy efficiency through ICT `http://news.zdnet.co.uk/internet/0,1000000097,39627516,00.htm`
[2] GeSI `http://www.gesi.org/`
[3] The Climate Group `http://www.theclimategroup.org/`
[4] EnergyStar `http://www.energystar.gov/`

low" in organisations. Clearly, some rationalisation should be possible if the correct data and incentives are made available to business policy makers and managers.

C. Green ICT (dis)incentives

We take the position that, in today's ICT environment, the incentives are wrong for wide-scale implementation of energy-saving policies, and useful information is not available from deployed systems to help business policy makers and managers move towards energy efficiency.

Firstly, energy-saving equipment and energy-saving tools often add additional cost to basic ICT purchases for end users, e.g. lower power CPUs in server equipment are optional 'upgrades'. Where total cost of ownership (TCO) considerations are made for purchases, these usually do not include energy-usage estimates, and operational and/or functional requirements to the business objectives are key. Furthermore, the installed base of (legacy) equipment may not have suitable hardware for energy monitoring, let alone permit energy control. Even when money can be found for purchase and installation of energy-usage monitoring hardware (e.g. for legacy systems), there is lack of an information model that permits appropriate collection of energy-usage and resource-usage data for devices within an administrative domain.

Secondly, for new equipment, established vendors currently use proprietary energy-saving features to compete for sales and maintain their customer base. So, there is little incentive for the established vendors to co-operate and agree cross-platform energy saving information models to allow ICT managers to be better informed about energy usage of deployed infrastructure. As very few ICT environments are single-vendor provisioned, this means that there are a disparate set of devices and components, all energy-aware, but whose energy usage is not easily visible to systems managers in an easily accessible or consistent manner. So, rationalisation of systems for greater efficiency within a single administrative domain is not easily possible.

Commercial providers such as EnergyICT[5] offer proprietary services for energy management, but these are expensive to deploy, and are aimed at larger organisations.

What are the correct data and incentives for business policy makers and managers? The NCC report [6] makes clear some key issues from its survey:

- Only 13.4% of organisations monitor power consumption, and there is little knowledge or experience about being green.
- Legislation, current and proposed, is *not* a major incentive to be green: cost savings are the *overwhelming* incentives.

II. Monitoring system-wide energy usage

"If you can not measure it, you can not improve it."
–Lord Kelvin

Our aims in this proposal are simple and address the two key issues above: lack of monitoring and awareness of the potential for cost savings on energy usage. We will produce and make freely available:

- a prototype *information model* for energy-usage monitoring. The information model will have the potential to be widely applicable to various common equipment.
- a software-based prototype solution that can be used for monitoring systems, based on the information model we produce. The software will leverage existing systems monitoring capability (including open source) wherever possible, to enable deployability.
- a prototype *monitoring application* showing the energy-usage for an ICT infrastructure as a mechanism for indicating the savings that can be made in energy costs.

We will develop, deploy and test the prototypes listed above on the systems of the University of St Andrews, i.e. the operational IT Services infrastructure for the University. We will make available for free the prototypes that we develop. Subject to final approval from the University and any constraints of the Data Protection Act, all the data collected during our development and testing, including energy usage data, will be made freely-available for use by other researchers and industry.

III. Researchers

The research will be lead by *Saleem Bhatti*, a Professor at the School of Computer Science at the University of St Andrews. He was Director of the e-Science *National Centre of Excellence on Networked Systems* at UCL, and is now the Theme Leader for the Scottish Informatics and Computer Science Alliance (SICSA) *Next Generation Internet* Theme. His past work covers network and systems monitoring and management; network architecture; mobile systems; network security; QoS (Quality of Service); adaptive systems; and high-speed networking. He is also involved with industry in various consultancy roles in the area of networking technology and systems, including work for OFCOM. EPSRC-funded projects include: GR/R73874 "Network Resource Scheduling", using dynamic resource control for the first demonstration of multi-gigabit reservations over a national infrastructure; GR/S93707 "IPv4 and IPv6 Performance and QoS" examining the monitoring and performance of high-speed protocols; and EP/G049874/1, "India-UK Advanced Technology Centre (IU-ATC) in Next Generation Networks" (ongoing) looking at energy-aware network management for future networks.

IV. Partners

Dr Malcolm Bain is Director of campus-wide IT Services (ITS) at the University of St Andrews. There is a growing focus on the energy that is being used within the University on computer systems. There are *c*140 servers in IT Services and *c*8,000 workstations connected to the network, presently with very little power monitoring taking place. A new data centre is being built with significant power requirements for the 24 equipment racks it will contain: the incoming power feed to the data centre is to be 420kVA. Having an information model

[5] EnergyICT `http://www.energyict.com/`

and a management application to report power usage on a per-system level will have significant benefits as described in this proposal. We should also be able to use this information for service level management reporting, which is another growing requirement.

Dr Richard Mortier is co-founder of Vipadia Limited, a Cambridge-based startup providing IP communications expertise. Relevant specialities include scalable architecture, implementation and integration, and network measurement and monitoring. As a recent startup, they are not affected by the disincentives listed above, and actively promote new and disruptive systems and technologies.

V. Timeliness, relevance and impact

The continuing increase of energy prices, the concerns about energy usage, energy supply and CO_2 emissions, and the expected growth of ICT usage all mean that inefficient energy consumption by ICT infrastructure needs to be addressed quickly. Cost savings from reduced and optimised energy consumption are very relevant to the development of the Digital Economy, in making online services efficient, sustainable and accessible for the future. Reducing CO_2 emissions is a key factor in controlling climate change. From the REF report [2], it is clear that reducing predicted future electricity usage will be important to sustainability of electricity supply in the UK. With increased use of ICT services in all aspects of life, there is potential for direct and significant societal impact from the energy monitoring capability. The availability of energy usage information directly from the operational ITC infrastructure will permit business policy makers and managers to define green KPIs and monitor their use, relevance and impact within their business processes.

VI. Route to impact

Working with St Andrews ITS and Vipadia, we will provide timely and widespread impact through the open and free availability of:

- an *information model* that includes energy information, including prototype software for monitoring.
- a prototype *monitoring application* that can make use of our information model and demonstrate the efficacy of our approach, and indicating the potential cost savings.
- data from our monitoring of the University of St Andrews infrastructure for use by other researchers and by industry to encourage a rigourous and scientific approach to development of energy usage management for the future.
- the potential for creating a new market for training, consulting and further systems development, based on the software tools and data listed above, and the expertise gained in undertaking the project work.

At the 15-month point, we expect to start investigating further plans on how this model can be adopted on a larger scale, for example to push the information model into relevant standards. To complement the software that will be freely available, Vipadia will work with St Andrews and SICSA Knowledge Transfer Offices on investigating the potential for (commercial grade) management applications that will use the information model.

VII. Resources

Our work programme will have four workpackages, with simple, realistic goals for an 18-month timescale:
WP1 Project Management (M01-M18). To cover management of the project and partner liaison; dissemination of results within the academic and industrial sectors; and forward planning for route to adoption.
WP2 Planning, procurement deployment of basic monitoring capability (M01-M06). We will plan the deployment and leverage of software tools that may already be available for system monitoring, and enable basic power monitoring for some devices using new power meters.
WP3 Design, specification and implementation of prototype information model and software agent (M5-M12). Based on WP2, the information model will be implemented as a software agent.
WP4 Design, definition and implementation of a prototype management application (M11-M18). Based on the information made available in WP2, we will design and build a prototype management application that allows basic monitoring and visualisation of energy-usage information.
Equipment. General computing resources and networking capability will be from our normal lab facilities. Power meters will be required to collect energy usage information for the legacy equipment. Storage capacity will be required for the collected energy-usage data.
Staffing. Software development, testing, and deployment, as well as system measurement and analysis will be performed by a PDRA. We will require 75% FTE of a Technician to install, test and maintain the power meters. Bhatti will manage the project, lead the design and architecture, provide oversight of software development and testing, supervise the PDRA, and liaise with both St Andrews IT services and Vipadia.
Travel. We have planned 7 project meetings (kick-off and then once every 3 months). We expect to produce two papers at international conferences.

The estimated cost (80% of FEC) is £227,000.

References

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