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# Information Technology: a Green Problem? or a Green Solution?

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# Information Technology: a Green Problem, or a Green Solution?

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A computer hums gently on the desk, barely noticeable among the office chatter, clinking coffee cups, and squeaking chairs. In the space of a few decades, computers have become such an indispensable part of the office environment that for some, imagining an office without them would be like imagining an office without desks.

If we walk down the hall, however, we find that the hum turns into a roar: this is the corporate data center, filled with rack upon rack of servers supporting the IT infrastructure we enjoy without much noticing – servers which inform and entertain our customers, conduct our financial transactions, underpin our global commerce and services, and even solve problems for us to make our work easier or more efficient. If we wander into this room, we might be excused for thinking we have walked onto an Alaskan airport tarmac in winter: power is in evidence everywhere, aggressively pumped into all those racks of faceless computers, and yet the whole room is a refrigerator, just as aggressively pumping out the resulting heat.

The voracious appetite of the corporate data center for power and space is becoming more and more noticeable on national and global scales. A recent report by the US Environmental Protection Agency (EPA) notes that electricity consumption by data centers has doubled between 2000 and 2006 to 61 billion kilowatt-hours (kWh), or 1.5% of total US electricity consumption – an amount exceeding that of the nation's color televisions. Demand for IT infrastructure, however, remains very strong, with double-digit growth expected year-on-year.

The IT industry, it must be said, recognized these challenges some years ago, and already some healthy trends are in place. Low-power processors, once considered a niche product, are now in mainstream computers. Server virtualization has become a very popular solution for consolidating services on a single machine. After some embarrassing mishaps, data center designers are increasingly careful to take power and heat into account. Oddly, however, some data center operators proudly display their power distribution panels and air conditioning units on their websites as if they were fancy sports cars.

The EPA report notes that there are potential environmental benefits to these data centers in that they may lead to efficiency gains elsewhere. For instance, a warehouse might change the order in which pallets are shelved or retrieved in order to reduce the overall petrol usage and hence carbon footprint of its forklifts. Sufficiently complex optimization problems, however, require considerable computing power. Ironically, it is generally not clear, for a given problem, that the environmental saving is greater than the environmental cost of the calculation which obtained it, especially when one considers all the costs of buying, installing, power, and cooling the computers – not to mention actually doing the “green” calculation.

<sup>1</sup> EPA Report to Congress on Server and Data Center Efficiency (Response to Public Law 104-431), 2 August 2007.

<sup>2</sup> Names will not be mentioned.

Existing data centers providing utility (or “cloud”) computing services could provide the IT resources for such calculations. Indeed, for some tasks, only a data center solution will suffice. However, in a real sense, this solution simply moves the problem elsewhere. These services must stock and maintain their data centers just like anyone else, and in order to provide a reliable level service, they must buy extra capacity like everyone else – the average data center generally uses only a third of its computing capacity – and expend half of their energy to power and cool them. On the other hand, if we are looking for the largest resource in the world, with the greatest capacity to absorb wildly fluctuating demands without incurring huge additional costs, then we must look elsewhere. We turn, instead, to those ubiquitous computers, humming away almost unnoticed on our desks, looking more like furniture than part of the world’s biggest, untapped computing resource.

There are some one or two billion computers in the world, many of which are considered essential to individual productivity but typically use less than 5% of their capacity even when “busy” – writing an e-mail, for instance, or editing an article. The spare capacity of these computers is such they could make up a supercomputer over 100 times more powerful than the current 500 most powerful supercomputers combined; at present, however, this capacity simply goes the waste, amounting to some £100 billion (counting only capital cost) thrown away every year. The cost of tapping into this resource, however, is determined largely by the marginal increase in electricity usage; the need for special powering and cooling infrastructure is virtually eliminated, since the computers are not confined to small spaces, as they are in data centers. Using these computers could therefore change dramatically the cost-benefit analysis for performing a “green” calculation.

There are, of course, considerable technical challenges to harnessing so many computers. Fortunately, we are now in a position to make important steps on the way using a technology called “Nereus”, which was developed in Oxford University’s high-energy physics research group for just this purpose. In order to visualize the scale of the problem which inspired Nereus, imagine a stack of CD’s forty kilometres high – three times higher than a commercial airliner flies. This is the amount of data we expect to record and process from the Large Hadron Collider, now beginning operations at the European Center for Nuclear Physics Research (CERN).

Nereus allows individual computers to join a worldwide network of computers willing to participate in large-scale computations and network-based services. Joining can be as easy as clicking on a link in a web page; the link downloads onto the host computer a Java applet which contains the foreign code. The Java applet’s security system assures the host computer’s user of its safety, and that the unfamiliar, foreign code will not be able to read his files or scan his passwords; Java applets are the best-established security context on the World Wide Web, having been used to run safely unfamiliar code from unfamiliar websites for over a decade. Moreover, the individual computers can be further protected by a corporate firewall and still fully participate in a Nereus network.

<sup>3</sup> Top500.org, <http://www.top500.org/>, 2008; Nolan J Taylor, “Public grid computing participation: an exploratory study of determinants, *Inf. Manage.*, 44(1):12-21, 2007; David Anderson, “BOINC: a system for public-resource computing and storage”, *Fifth IEEE/ACM Intl Workshop on Grid Computing (GRID’04)*, 2004.

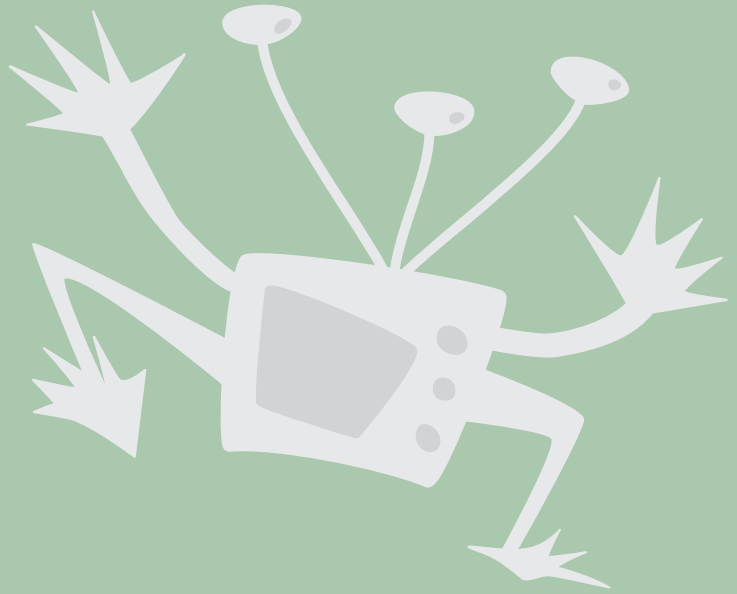
<sup>4</sup> Technical information can be found at <http://www-nereus.physics.ox.ac.uk/>.

The manner of joining individual computers to a Nereus network allows corporate system administrators to circumscribe the activity of the company's Nereus nodes, including the ability to restrict overall network bandwidth consumption as well as the sites from which foreign code can be downloaded. Perhaps more interesting is that Nereus can facilitate a quid pro quo arrangement between companies: one company could allow another to use its machines for agreed purposes at times of peak demand if the other returns the favour. In this way, both companies avoid the capital expense of expanding centralized data centers and their associated infrastructure, instead getting more use, at marginal cost, out of computers already bought for other purposes.

Nereus therefore has the potential to pull the IT industry out of a rather ironic position: the industry recognized its energy challenges well before they showed up on government radars, and indeed, for many years it successfully promoted the use of computers to decrease paper use in offices and increase the efficiency of everyday machines such as automobiles. It is an odd and uncomfortable situation for the industry itself to be fingered as an environmental problem. By overcoming the challenges of safely mustering these existing computers and looking beyond the corporate data center to tap into the world's largest – and heretofore mostly unused – resource, Nereus can change all that again. IT should once again be part of the “green” revolution. Nereus brings us closer to that reality.

#### About the Author

Dr Jeff Tseng is a University Lecturer in the Department of Physics, University of Oxford, having previously held research positions at MIT and the Fermi National Accelerator Laboratory. He is the founder and leader of the department's Interdisciplinary Grid Development (IGD) group which is responsible for JPC, a Java-based x86 PC emulator, and Nereus, a runtime environment for network programming. He is a member of the ATLAS experiment, based at CERN's Large Hadron Collider (LHC), where he investigates fundamental symmetries and structures of Nature, including microscopically curved extra-spatial dimensions and micro-black holes. He is also the Software Coordinator of the ATLAS Upgrade Project and a member of the experiment's High-luminosity Upgrade Steering Group and Software Project Management Board.



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