Subject: Press Inquiry from Technology Research News (www.trnmag.com)

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From: Ted Bowen (Editor) <tbowen@trnmag.com>

To: rajkumar@csse.monash.edu.au, jon@csse.monash.edu.au, davida@csse.monash.edu.au, heinz.stockinger@cern.ch

Greetings -

I'm looking to write a brief article for Technology Research News (www.trnmag.com) on your Grid computing study. If you're willing to participate, please reply to the following questions at your soonest convenience?

Thanks -

Ted Bowen, contributing editor

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Rajkumar Buyya with inputs from his colleagues and collaborators David Abramson and Heinz Stockinger answers to press inquiry from the Technology Research News (www.trnmag.com). We believe our recent paper on:

* Economic Models for Management of Resources in Peer-to-Peer and Grid Computing

has attracted world media attention. The paper co-authored by Rajkumar Buyya, Heinz Stockinger, Jonathan Giddy, and David Abramson appears in the Proceedings of the Commercial Applications for High-Performance Computing Conference, SPIE International Symposium on The Convergence of Information Technologies and Communications (ITCom 2001), August 20-24, 2001, Denver, Colorado, USA. The work described in the paper is a results of collaboration between researchers from Monash University, CRC for the Enterprise Distributed Systems Technology (DSTC), Melbourne, Australia; and CERN–European Organisaton for Nuclear Research, Geneva, Switzerland where the World Wide Web (WWW) was born. The results presented in the paper are derived from our investigation on hundreds of jobs scheduling experimentation using Nimrod-G resource broker on the World Wide Grid (WWG) testbed spanning across five continents as of June 2001.

Full paper and Grid software tools are available for download from the Economy Grid project home @ http://www.csse.monash.edu.au/~rajkumar/ecogrid/

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## Answers to the Technology Research News Magazine Questions

*1) What's your assessment of the current market for distributed computing services? Given the prevalence of application service providers, outsourcing companies, online exchanges and the like, would you say that some of what you discuss is already being implemented? If not, what's the distinction?*

The current market demand for distributed computing services is rapidly growing. The computing trend is moving away from *compute-inside-the-box* to *compute-out-side-the-box* leading what is called ***service-oriented computing***. It is being predicted that Software's Next Leap Is Out of the Box, which is not surprising due to proliferation of lightweight mobile devices for transparently accessing applications from remote resources. All those efforts such as ASP, outsourcing, online exchanges, etc., are certainly creating necessary building blocks for realizing the vision of network-based service-oriented computing. Two other technologies that are rapidly emerging in the recent past are Grid and Peer-to-Peer computing currently promoted by the academic and commercial communities respectively. The most important bit

that is lacking in all these efforts is availability of services that are driven by users quality-of-services (QoS). This is where our work comes into the picture. We are focusing on the use of economics as a metaphor for management of resources and scheduling in peer-to-peer (P2P) and grid computing as this provides a mechanism for regulating supply-and-demand for resources depending on users' QoS requirements. It provides economic incentive for both resource owners and resource providers for playing their role as good citizens. There is a saying "price is what you pay and value is what you get?" Many technologies that are in use and even those promoted as next generation solutions adopt a system-centric approach in resource management where users do not get the value for the price they are paying and it is hard to provide any QoS that can vary from users to users and applications to applications depending on the importance of the problem at the time of execution. In that aspect, our solutions are unique and they offer simple, but effective mechanism for regulating the supply-and-demand of resources in such a way that users' QoS demands are met. More importantly, it offers incentive to all for being good citizens while providing or consuming shared resources.

*2) Your experiment was carried out on the five-continent Grid configuration detailed in your paper. How widely applicable do you think your economic models would be?*

The Grid and P2P tools and technologies that are developed using our economic models enable service provision and pricing based on applications QoS demands and supply-and-demand for resources. They can be used in executing science, engineering, industrial, and commercial applications such as drug design, automobile design, crash simulation, aerospace modeling, high energy physics, astrophysics, earth modeling, electronic CAD, ray tracing, data mining, financial modelling, an so on.

*3) Can you elaborate on the differences between the management requirements of Grid and peer-to-peer configurations and those of 'traditional' networks?*

The management requirements of P2P and Grid configurations will have to be much smarter, dynamic, adaptive, failure tolerant than network systems. In P2P and Grid systems, applications aggregate and simultaneously consume services from many resources from many providers, depending on QoS demands from end-users. It also varies one application area to another. In traditional networks, systems architecture is mainly driven by client-server paradigm, so dynamism present in those systems is limited. Like in telecommunication networks, the granularity of automating management and handling of issues related to pricing, accounting, and payments are larger and hence there is less implementation complexity in Grid and P2P computing compared to supply-and-demand driven price-based routing of Internet packets.

*4) Are the protocols and broker/service provider/directory systems described in your study intended as examples, or will they be developed as production systems or standards?*

Currently we are engaged in research, development, and implementation of necessary tools and services such as Nimrod-G Computational Resource Broker, DataGrid broker, Grid Trading Services, Grid Market Directory, and Grid Bank using services provided by middleware solutions such as Globus. We have been using our resource broker for scheduling computations of Drug Design application, involving screening of molecules on our WWG testbed. As our tools get established, they will be deployed on to production systems such as APAC (Australian Partnership for Advanced Computing) and VPAC (Victorian Partnership for Advance Computing) resources for routine use.

*5) Do you anticipate the use of these economics-based models for grid and P2P systems first among researchers and then among the business community? What's the expected progression?*

Given rapid movement among the business community focusing on the deployment of P2P systems, we think that the business community is likely to first embrace the wide spread usage of economic models. They are likely to be embraced by academic consortiums/partnerships for sharing resources to support their researchers or providing computational services for government sponsored projects. In fact, they already have resource allocation strategies in

the form of tokens or credits, but they are mostly bound to a particular resource, and value of those tokens or credits is mostly fixed irrespective of their value to the user at the time of usage. It is expected that when software tools like ours are available for production use, we believe the research community will embrace the usage of our economic models.

*6) In section 3.9, you allude to 'broader' influences. How would you see things like the General Agreement on Trade in Services (GATS) and other WTO policies/initiatives affecting this scheme?*

This is rather difficult to answer since the GATS and WTO influence on common markets is not really transparent. We might assume that international organizations will have some influence but only to very restricted markets and certain goods.

*7) Who maintains the WWG?*

Our current World Wide Grid (WWG) testbed comprises of resources (Linux PCs, workstations, clusters, etc.) distributed all over the globe. Those computational resources are owned by different organizations and they are responsible for maintenance of their own resources. We use our resource broker called Nimrod-G to aggregate WWG resources on demand to create a active Grid on the fly. The resource broker automatically leases necessary resources competitively, depending on the QoS requirements such as deadline and budget constraints. The end users set these constraints depending on the value their needs and the value they derive from results, which varies from time to time.

*8) When would you anticipate widespread use of such management/brokering systems for Grid and peer-to-peer computing?*

Already, government sponsored programs in many countries including Australia are encouraging the creation of production Grids for the use of academic and research communities in solving large-scale science and engineering problems. They will be the first users of our management and brokering systems. We have received positive responses from industries on our work. They too believe that economics is a fine metaphor in managing resources and organizing computations. Depending on market forces, we believe that it will take two or three years for widespread use of economic models for Grid and P2P computing. This can even happen soon as killer tools or applications like Napster for music files sharing changing from free to priced services. Similar killer tools for sharing all sorts of resources including computers, contents, instruments, databases, software/applications driven by economic incentives can fire up rapid adoption and progress in usage of such economic and QoS driven model in service oriented P2P and Grid computing.

We are pleased to inform you that we have already commercialized an early version of our work that does not use economic models. Nimrod, our earlier tool available as enFuzion commercially is meant for formulation and execution of legacy applications as pleasantly parallel, parameter-sweep applications on a cluster of computers owned by a single organization. Our existing users are most likely to accept and embrace our new economics driven technologies and tools such as resource broker (Nimrod-G) and resource trading middleware developed within the Economy Grid project framework. With new technologies, the users need not own expensive resources (computers, software, etc.). On demand, their resource brokers lease services that are necessary to meet desired QoS requirements such as deadline, spending limit, and importance of the work-to-be-completed. Our technologies help both resource consumers and providers to manage the whole scenario automatically. We believe service oriented computing coupled with economic models in P2P and Grid computing can lead to a new paradigm shift within computing industry.

*9) What was the source of funding (or sources) for the study?*

Our work is mainly supported by grants and scholarships from the Australian Government agencies, Monash University, CRC for the Enterprise Distributed Systems Technology (DSTC), and the IEEE Computer Society. Our collaborator Heinz Stokinger's work is supported by CERN, the European Organisaton for Nuclear Research in Geneva, Switzerland through a European Union funded DataGrid project.