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Prospects for Grid-Computing in Future Power Networks

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1. Introduction

The word 'Grid' in Grid-computing was chosen by analogy with the electrical network. The idea is that computational resources should be as readily available as electrical energy by simply 'plugging in to a Grid'. This short article is intended to alert the power system community to the concept of Grid-computing and to initiate a discussion of its potential applications in future power systems. Can the computing 'Grid' offer new solutions for the generation, transmission, distribution and power utilisation systems of the future? Some of the questions to be considered are: what is Grid-computing, why is it being developed, and what could it do for power systems?

2. Grid-Computing

Grid-computing has a good pedigree. It is championed by the same people that brought us the World Wide Web, i.e. the particle physics research community. They are introducing this new software technology to fill an immediate and real need. Present generation particle-accelerators produce such huge volumes of measurement data, at such high rates, that a new approach is needed to enable the information to be processed, analysed and interpreted by thousands of collaborating scientists throughout the world. To quote from the UK funded GRIDPP web site [1]:

> *The next IT revolution will be the Grid. While the Web is aimed mainly at the exchange of information, the Grid is concerned with the exchange of computer power, data storage, and access to large databases, without users searching for these resources manually. Computer services will become a utility like electricity, supplied via a Grid. Once connected to the Grid, the end user will see it essentially as one large computer system. The Grid is a practical solution to the data-intensive problems that must be overcome if the computing needs of many scientific communities and industry are to be fulfilled over the next decade.*

Can future power networks benefit as a spin-off application? In power systems, as a result of the move to renewables, a larger number of smaller generators will call for more active and dynamic operation, especially at distribution level. The future power system will involve many participants: generator owner/operators, generator maintenance providers, generation aggregators, transmission network operators (TNOs), distribution network operators (DNOs), load managers, energy market makers, energy supply companies, metering companies, energy customers, regulators, and governments. Grid-computing could offer an inexpensive and efficient means for participants to compete (but also co-operate) in providing reliable, cheap and sustainable electrical energy supply.

2.1 *The nature of Grid-computing*

Grid-computing, or 'the Grid' for short, uses standard open-source (non-propriety) software to allow a large number of users to share computational resources. In contrast to the limited information sharing provided by the Web, *all types* of computational resources can be shared (i.e. data stores, algorithms and processing power). The sharing of resources is by no means a 'free-for-all', however. Access to shared resources is carefully controlled. The computers participating in a Grid create a massive distributed system and the users become part of a ‘virtual organisation’.

2.2 *Grid-computing and distributed computing*

In the early days of computer networking, various specialised systems enabled file transfer and e-mail within universities and research-led organisations. The introduction of the Web allowed that technology to reach critical mass and develop into the system that we are familiar with today. In a similar way, Grid-computing culminates from earlier developments in ‘distributed computing’ and is widely predicted to be the ‘next big thing’ in computing.

2.3 *Grid-computing and the Web*

Like the Web, the Grid can operate over the Internet or any other suitable computer networking technology. How does the Grid differ from the Web? Some of the significant differences are show in Table 1.

The ‘Web’	**The ‘Grid’**
Low-volume information sharing	high-volume information sharing, distributed computational processes, and computer power sharing
there is only one Web	there are many separate and distinct Grids
anyone can ‘join’	a Grid has a carefully controlled set of registered participants
no intrinsic reliability and security of data transmission	reliable and secure data transmission
no inherent protection against misuse	certification, authentication, etc. is built in

Table 1: *Differences between the ‘Web’ and the ‘Grid’*

3. <u>Characteristics and Capabilities</u>

Some of the relevant characteristics and capabilities of Grid-computing are:

- A Grid is created by installing software services, or middleware (e.g. the Globus Toolkit [2]), on a set of networked computers. The middleware provides facilities such as: hardware and software resource location, user authentication, and distributed scheduling of resources and tasks.
- Grid-computing is designed to be scalable (e.g. a Grid should operate equally well with 100,000 participants as with 100).
- Grid-computing is often regarded as a means for creating inexpensive ‘super-computing’. It is now becoming clear that an equally significant purpose is to enable inexpensive, scalable, reliable and secure distributed computing, usually across corporate boundaries.

4. Potential Benefits for Future Power Systems

Grid-computing could have very significant benefits for almost all the aspects of power systems that involve computers. In the following discussion it is assumed that in the future every electrical generator will be equipped with computational and communication facilities. This does not seem too far-fetched in a world where cars, vending machines, domestic appliances etc. are predicted to be similarly equipped.

4.1 *Monitoring and Control*

It is anticipated that a large numbers of smaller generators will be introduced in the coming decades, utilising renewable energy and reducing carbon emissions. As these generators are connected into the power system (often embedded at distribution level) it will become necessary to monitor and control their output level and their on/off schedule. The control technology in use at transmission level is not scalable to very large numbers of generators. Grid-computing can provide a relatively inexpensive new technology, allowing the output of embedded generators to be monitored and when necessary controlled.

An outline of a power systems Grid-computing structure is illustrated in Figure 1.

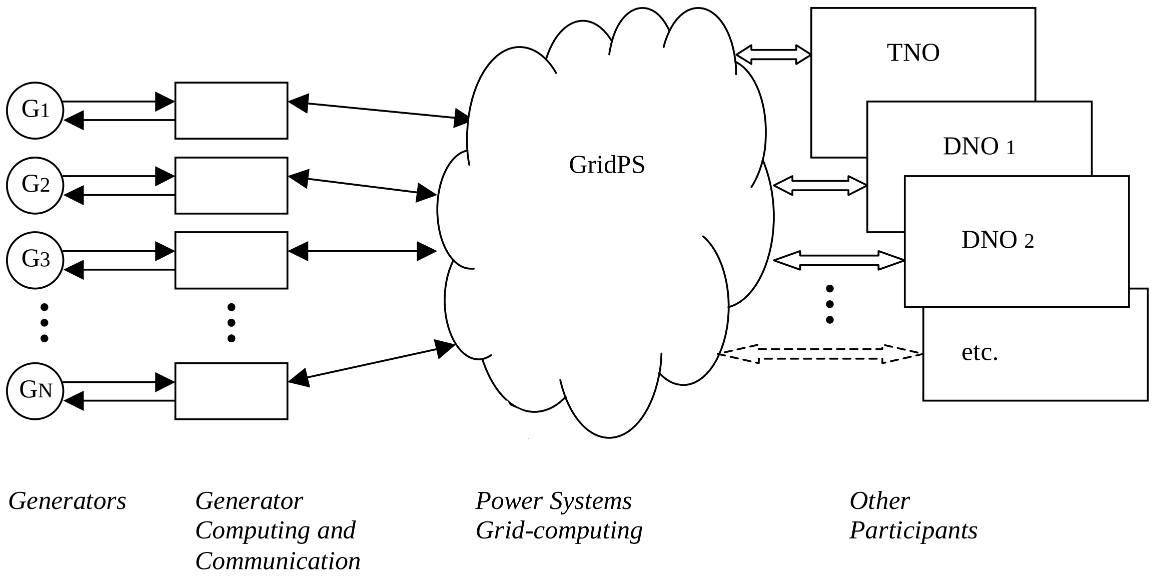

Fig. 1 *Outline of a power systems computing Grid*

4.2 *Market Entry and Participation*

Future electrical energy markets should provide open access to a range of participants from very small organisations (perhaps even individuals) to very large companies. The need to register in the market, receive and transmit financial information, notify the market of technical constraints, etc. can all be provided by Grid-computing. The ability of Grid-enabled systems to interact autonomously will be vital for small generators where manned operation is unlikely to be viable.

4.3 *Regulation*

A power system computing-Grid would provide regulators with access to complete information on the technical and economic performance of regulated markets. New regulatory rules and incentives could be introduced and disseminated electronically.

4.4 *Planning*

Planning of future power systems will rely on a collective effort by many companies and agencies. The sharing of accurate, detailed information on the existing system and the ability to use industry-wide computer models and forecasts would facilitate a co-ordinated approach. The creation of a 'virtual organisation' including all relevant participants could retrieve some of the benefits of global planning that are often claimed to have been the main advantage of the centralised, vertically-integrated industry that existed before privatisation.

5. Further Development

More than 20 projects are already underway to develop and exploit Grid-computing. The UK research effort includes a £98million initiative, established by the Office of Science and Technology. A National e-Science centre has been created with a number of regional centres [3]. Considerably greater funding has been made available in the EU and the USA. Major computer manufacturers are already seriously committed. However, to our knowledge, there are no projects underway to investigate power system applications. At Brunel University, power system and Grid-computing research teams are collaborating and have obtained funding to underpin research in this area. It is hoped that this field will develop rapidly over the next few years, bringing forward a new technology with significant benefits for the power networks of the future.

6. Conclusions

This short article has introduced the concept of Grid-computing for power systems. The authors would be happy to be contacted by anyone interested in taking the discussion further. References [4] and [5] provide an excellent introduction to Grid-computing technology.

7. Further Reading

1. http://www.gridpp.ac.uk/

2. http://www.globus.org/

3. http://www.nesc.ac.uk/

4. Foster and C. Kesselman (eds.): 'The Grid: Blueprint for a New Computing Infrastructure', Morgan Kaufmann, 1999, ISBN 1-55860-475-8

5. F. Berman, G. Fox and A.J.G. Hey: 'Grid Computing: Making the Global Infrastructure a Reality', John Wiley, 2003, ISBN 0-470-85319-0

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