Organisation for Economic Co-operation and Development

Global Science Forum

Report on
GRIDS AND BASIC RESEARCH PROGRAMMES

Final consensus report from the OECD Global Science Forum Workshop
held in Sydney, Australia, on September 25-27, 2005

1. Introduction: Grids and e-Science

The linking of individual computers into increasingly complex networks has been transforming the scientific enterprise for several decades. Networking has affected every aspect of research, including data-gathering, sharing of large databases, brute-force computing, modelling and simulation, and publishing of preprints and papers. A major step in this transformation was the invention of the World Wide Web (WWW) at CERN in 1990. The power of the WWW comes from the wide-scale adoption of standards, formats and protocols for sharing and displaying information via the Internet. Today, a new set of network-centred breakthroughs are emerging under the collective label of "Grid Computing" or "Grids". While there is no universally acknowledged definition, the essence of Grids is that they utilise highly sophisticated, flexible network architectures, and that they involve the sharing of all computing resources, not just data. Notably, shared resources include computing power itself. Among the most important characteristics of Grids are the following:

- The set of computers that makes up a specific Grid application can change quickly (within minutes or even seconds) depending on need and availability.
- The linked computers may be very heterogeneous (in terms of CPU type, performance, operating system, peripherals).
- The sharing of data and computing resources is based on standards and protocols that guarantee reliability, trust, authenticity, and security, and that automatically keep track of costs and accounting information.
- Access to any given application (and to resources) is automatically allocated and/or restricted based on pre-agreed rules. In the future, Grid software will autonomously seek out and allocate to itself the tools that it will need, in real time.
- While Grids are based on a large set of sophisticated software modules (known generically as "middleware"), the complexity of the system is hidden from the average user, who does not need to manipulate, monitor, or even understand the way that the system is responding to the user's needs for data and computing power.
- Grid software has, to date, been primarily developed in an "open source" environment, where the computer code (that of the middleware modules, for instance) is made available to everyone, and can be adopted and modified by others, as long as proper attribution is ensured[1].

[1] Open source software can be licensed to vendors, who can add value to it, thus creating a marketable product.

Many experts believe that, within the next two decades, Grids will have an impact that is comparable to that of the WWW. At the present time, and as was the case for the WWW (and, indeed, the Internet itself) the development of Grids is, for the most part, in the hands of the worldwide scientific community. Scientists are applying the new technology to solve ever-more-difficult computational and data management problems across a wide range of domains, from fundamental physics to climate modelling. More importantly (from the viewpoint of the OECD Global Science Forum) Grids are being created and used to implement innovative types of international, interdisciplinary collaborations.

The new network-intensive and network-centric mode of research is sometimes known as "e-Science"[2] – a way of conducting research that is explicitly dependent on advanced computer networks and which, in many cases, would not be possible without them. Some illustrative examples are:

- The next generation of very large facilities for research in physics and astronomy will probably be linked via Grids to users across the globe. The best known instance (and test-bed) is the Large Hadron Collider (LHC) at CERN and its "Worldwide LHC Computing Grid" (LCG). Future Grid-accessible facilities could include the International Linear Electron-Positron Collider, proposed 30-, 50-, or 100-metre optical telescopes, or the proposed Square Kilometre Array radio telescope. Some of the instruments (particle detectors, spectrometers, interferometers, etc.) will be monitored and operated from remote locations around the world. Future large <u>user</u> facilities (neutron or X-ray sources, for example) may also be routinely Grid-enabled. The needs of large facilities can provide the "applications pull" that will help to create grids that serve scientific communities and are hardened to meet real–world conditions.

- Extremely complex and/or data-intensive computations may become accessible to a much wider group of researchers via Grids that instantaneously link available computers and sources of data world-wide, and take advantage of their idle CPU cycles and unused memory space. Computations of this kind are common in fields such as biomedical informatics, Earth systems studies, earthquake engineering, and thermonuclear fusion[3].

- Interdisciplinary research using large heterogeneous databases needs Grid-type solutions for linking researchers from many fields and in many locations. For instance, the study of a particular disease may involve large genomic and genetic databases, large sets of data from PET/X-ray/NMR scanners, information about populations and medical clinical records, drug and molecular data, and other relevant data collections (some of which may incorporate privacy safeguards). The researchers, in turn, may be from distantly related specialisations. A collaborative project that is intended to produce a result in a short time (and is therefore unable to devote years to the development of special-purpose software) will only be feasible if generic Grid-type applications can be assembled into a reliable application in a short time. Such finite, transient, goal-oriented, international collaborations are sometimes referred to as "virtual organisations" (VOs).

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[2] The term was originally coined by Sir John Taylor, former Director General of the UK Research Councils. He was a speaker at the Sydney workshop. The Research Councils' definition reads as follows: "In the future, e-Science will refer to the large scale science that will increasingly be carried out through distributed global collaborations enabled by the Internet. Typically, a feature of such collaborative scientific enterprises is that they will require access to very large data collections, very large scale computing resources and high performance visualisation back to the individual user scientists."

[3] There is no intention of implying that Grids are a panacea for all computationally intensive or data-intensive research. Some projects will continue to require dedicated, centralised, or special-purpose computing equipment.

2. Potential for Benefits in the Public and Private Sectors

There is strong interest in Grids in the private commercial sector. Some companies are experimenting with Grids for applications such as product development, and for establishing optimal structures for collaborations with other industrial partners (based on the VO paradigm). For the latter type of project, companies are particularly interested in the features of Grids which allow for the establishment and enforcement of well-defined limits on the extent of sharing of resources. Thus, using Grids, a company will be able to collaborate with a competitor in a particular application domain while protecting the security of unrelated proprietary programs and data.

Private entities are also interested in Grids as profit-making entities in themselves, i.e., they are creating/marketing/servicing middleware and complete applications, as well as special purpose hardware that will be needed for Grid-based projects. There is some concern that the prevailing open source development paradigm may not be applicable for this type of activity, though it is possible for a private for-profit firm to build proprietary applications on the basis of open source software, and market them for profits, provided that the intellectual property rights are legally obtained.

Governmental agencies are also beginning to explore the potential of Grids for non-research applications, such as providing government services to the public, and extending the current uses of the WWW for serving the public. Some critical future applications could explicitly take advantage of the fundamental characteristics of Grids. For instance, in the face of large natural or man-made disasters, emergency management agencies could implement pre-prepared Grid-based applications (for example: to compute locations of maximum earthquake damage, to plan evacuations, to model the spreading of a disease outbreak). In time of need, emergency agencies could pre-empt the resources that they would require, without having to have such resources idling on standby during non-emergency periods.

3. Rationale for the Global Science Forum Workshop

The Global Science Forum of the Organisation for Economic Co-operation and Development is a venue for consultations among senior science policy officials of the OECD member and observer countries on matters relating to fundamental scientific research. The Forum's activities produce findings and recommendations for actions by governments, international organisations, and the scientific community. The Global Science Forum's mandate was adopted by OECD science ministers in 1999, and an extension until 2009 was endorsed by ministers in February 2004. The Forum serves its member delegations by exploring opportunities for new or enhanced international co-operation in selected scientific areas; by defining international frameworks for national or regional science policy decisions; and by addressing the scientific dimensions of issues of social concern.

The Global Science Forum meets twice each year at OECD headquarters in Paris. At these meetings, selected subsidiary activities are reviewed and approved, based on proposals from national governments. The activities may take the form of studies, working groups, task forces, and workshops. The normal duration of an activity is one or two years, and a public policy-level report is always issued. The Forum's reports are available at www.oecd.org/sti/gsf.

In July 2004, the GSF approved a proposal by the Australian delegation to convene a workshop on Grids and Basic Research Programmes. The proposal noted *inter alia*: "Grid programmes have been in progress in OECD countries for some time, e.g., in the US for over 5 years, in the UK, as a formal government supported programme for about 3 years. Early adoption of Grid programmes has been enthusiastic among the user community. Grids are highly relevant to a number of scientific domains that have been the subject of Global Science Forum activities in recent years: high-energy physics, astronomy, bioinformatics, neuroinformatics, and science education. Demonstrator projects have shown benefits but there has not yet been a systematic examination of the challenges and opportunities that are the chief concern of science funding agencies and science policy administrations, that is, topics that are appropriate for consideration by the OECD Global Science Forum." Thus, the OECD workshop focussed on policy issues, and did not examine specific scientific or technical questions which, in any case, are frequently considered during special-purpose meetings and conferences. Accordingly, this report focuses on the process through which Grids are being created and applied. The goals of the report are: to strengthen the links between Grid designers, developers, and users; to accelerate and optimise the implementation of Grids for supporting basic research programmes; to ensure that funding agencies obtain the best possible results in return for investments in Grids; and that the benefits of the new technology reach all countries, including those that are not in a position to make major investments in Grid development.

A critical examination of Grid policy issues is particularly appropriate and timely for the OECD. The organisation is in the vanguard of the over-arching process known as "globalisation" in which international entities (both public and private) are become increasingly inter-linked and inter-dependent. The benefits of globalisation in such areas as trade, investment, and telecommunications are well known. But there are risks as well, for example, potential losses of sovereignty, transparency or control at the national level, and the possibility of inefficiency, or abuse of trust. It is interesting to note that this mixture of potential benefits and risks emerged in the discussions about Grids at the Sydney workshop. Accordingly, the findings and recommendations in this report are aimed at maximising the benefits, and reducing the risks, associated with the major global-scale expansion of computer networks that is the essence of Grids.

Another incentive for GSF delegates to take up Grid issues is their often-expressed concern for promoting the transfer of technologies and practices from the relatively narrow world of scientific research to the broader social arena. As already stated above, there are very good reasons to think that Grid techniques and solutions will find their way into the public and private sectors, this providing another illustration of how public investments in basic research produce benefits for society as a whole.

The workshop was hosted by the Delegation of Australia and was held on September 25-27, 2005, in Sydney. It was attended by government-appointed delegates from thirteen Global Science Forum member countries[4], invited speakers, and the OECD secretariat. A list of participants is appended to this summary. The workshop preparations were supervised by an International Steering Committee that was appointed by interested OECD member countries. The workshop (and the Steering Committee) was chaired by Professor Ah Chung Tsoi of the Australian Research Council. This report to the Global Science Forum has been reviewed by the workshop participants, and agreed to by the members of the International Steering Committee. It contains findings and recommendations for funding agencies and for the community of Grid developers.

4. Findings Regarding Specific Technical and Policy Issues

Many issues associated with the development of Grids are purely technical, and no attempt was made to address these at the OECD's policy-focussed workshop. The findings that are enumerated below deserve the special attention of funding agencies and of the organised scientific community, i.e., the findings are about issues whose policy and technical dimensions are closely linked. Typically, these are ones where agencies can create conditions for Grids to develop in a more efficient way, and/or where further technical progress needs to be accompanied by enhanced dialog/co-operation/co-ordination, especially at the international level. In surveying the landscape of Grid-related activities world-wide, the OECD workshop participants were unanimous in expressing satisfaction with the work achieved to date, and enthusiasm for progress to come. However, some of the findings below describe deficiencies of the present situation. The motivation is obvious: any criticism is meant to point the way to improvements, so as to derive the greatest possible benefits from Grids for science and for society. That is, the intention is to make an existing good situation even better.

[4] Australia, Austria, Belgium, Denmark, France, Germany, Italy, Japan, Netherlands, New Zealand, Sweden, United Kingdom, United States

Finding A: Incorporation of Grids and e-Science into national plans, priorities, and procedures

While the benefits of Grid-type network architectures have already been recognised by some research funding agencies, the traditional requirements and procedures of most agencies are not, typically, well adapted for taking advantage of Grids, and do not promote the practice of e-Science. For example, project proposals usually have to identify the modalities (and costs) of external cooperation in detail and well ahead of time, whereas e-Science allows the spontaneous establishment of VOs on an "as needed" basis and for indeterminate periods of time. Sharing of data and computers is not always seen as desirable, encouraged, or rewarded. That is, agencies and research institutions are reluctant to pay for resources that will be utilised by others, especially when the details of the utilisation cannot be specified in advance. Researchers themselves often do not partake of the culture of sharing (even though they may pay lip service to it) and are disinclined to make their information and computing resources available to a wider community of scientists via Grids. Some of the reluctance is due to the significant effort that is needed to select, format, and annotate data to make it accessible and comprehensible, which is often not funded as part of a scientific project.

Finding B: Ensuring optimal development and quality of Grids

To date, the evolution of Grids has largely proceeded in a spontaneous, "bottom-up", investigator-driven mode. As a result, numerous projects and implementations have evolved independently, each with a separate set of specifications, requirements and solutions. The following Grid implementations (sets of standards, protocols, middleware, etc.) are available today: Globus Toolkit, Virtual Data Toolkit, the EGEE distribution in Europe, the distribution by the National Middleware Initiative in the US, the Open Middleware Infrastructure Initiative (OMII) distribution in the UK, UNICORE in Germany, INFN Grid distribution in Italy, and others[5].

Because of the exploratory nature of some projects, there have been instances of "test bed" implementations that were completed without adequate final testing, documentation, or other elements that are needed to motivate users to adopt the results for actual applications. Commitment by potential users requires a belief that Grid software will be supported throughout the anticipated application period. The absence of such a belief is an incentive to develop yet another new customised Grid architecture, which may constitute an inefficient use of time and resources.

While acknowledging that exploration and experimentation should continue (see Finding G), some OECD workshop participants expressed the view that it is time for the field to consolidate, and to move forward in a more systematic and coordinated way. The codification and adoption of standards and finished software packages would allow everyone to benefit from existing proven solutions, and would eliminate some redundant activities ("reinventing the wheel"). Such a process would have to be undertaken with great care, striking a correct balance between diversification and consolidation. It would require an open but structured dialog between high-level system architects, implementers, users, and, if appropriate, representatives of funding agencies and/or private companies.

Even if the right amount of consolidation and standardisation is achieved, there will continue to be multiple Grid architectures, standards, and implementations. In many cases, considerable benefits could accrue from having the implementations run together, i.e., from requiring them to be "interoperable". This is most particularly the case in research domains that are inherently interdisciplinary. Unfortunately, interoperability is not easily achievable and, when it is attempted, often takes the form of ex-post-facto fixes that are ad hoc, time consuming, and error prone. It is always better to anticipate interoperability requirements, and to explicitly design them into the high-level architecture of the individual Grid projects. This, in turn, requires an appropriate organisational and institutional mechanism.

[5] The list of projects and implementations in this paragraph is not intended to be complete.

Finding C: Anticipating long-term requirements for hardware and software resources

One of the most attractive features of Grid computing is that it allows for more efficient use of the already installed physical infrastructure. In effect, the networking of different types of computers world-wide can allow for much better "load balancing" and matching of supply and demand, including soaking up unused (idle) CPU cycles in those computers. The connection of large databases together via the network facilitates discovery of information and knowledge which were previously unknown. There are several well-known forerunner applications of this type (notably the SETI@home project, or the Skype Voice over IP system, although these are not in themselves Grid applications). Policymakers need to be aware of a potential hazard, however: as Grids become more widely adopted, the supply of under-utilised resources will diminish. Indeed, the ability to apply computer networks in innovative ways will most likely increase the need for additional computers, storage devices, high-bandwidth backbones, etc. Thus, there exists the potential for an undesirable neglect of physical infrastructure investments resulting from a complacent belief that useable resources will be "out there on the Internet", paid for by someone else[6].

A similar argument applies to software to some extent. The open source paradigm implies the use of many software modules without apparent cost. However, the development/documentation/support costs are very real and they should be accommodated by agency funding mechanisms[7]. In addition, software copyrighting needs to be better understood, since there is an inherent tension between the open source concept and the legitimate concerns of the private sector which seeks financial returns on its Grid investments.

Thus, the inherent distributed and shared nature of Grids gives rise to policy-level challenges that have to do with the planning and financing of hardware and software resources. To address these challenges at the global level, new consultative mechanisms may be needed.

Finding D: Understanding cost and payment issues

As Grids become more ubiquitous, and as they evolve from experimental to production modes, cost and payment issues will inevitably become more prominent. Potential users of Grid implementations must have a good understanding of how much it costs to use the system, and the basis on which the cost is computed. This is not a simple matter, since the type and quantity of utilised resources is subject to rapid change over short periods of time. Providers (of software, data, intellectual property, computing power, storage, bandwidth, etc.) will want to know whether and how they can recover their expenses and investments. Today, while Grid computing is still in the formative stage, there is already a need to analyse and compare various business models that are appropriate for Grids, i.e., ones that take into account the unique characteristics listed in Section 1. Different business models may well apply to Grid development and to real-time utilisation (accounting, billing, transferring funds, overheads, etc). These matters are obviously of concern to all Grid stakeholders: funding agencies, Grid builders, users, and the private sector.

Finding E: Guaranteeing data and resource security

As mentioned already, Grids are characterised by decentralisation, sharing of resources, flexibility and openness. With these characteristics comes the threat of abuse, and security violations of various kinds. Those who control (and are responsible for) the integrity of resources (such as CPUs, storage devices, data, software) will not allow them to be integrated into Grid systems unless they are confident that the resources will not be damaged, modified, accessed by unauthorised parties, abused or utilised in a wasteful manner. Today, with heightened concerns over national security, and with the proliferation of hacking,

[6] The provision of general-purpose or special-purpose computational resources, available for Grid-based applications, may represent a significant commercial opportunity for specialised companies in the future.

[7] One workshop participant quipped "the trouble with free software is that no one wants to pay for it".

viruses, Trojan horses, etc., there is a tendency to protect high-performance computer systems behind institutional firewalls. This can be a serious disincentive to the development of Grids, since a considerable effort may be needed to discover and access computing and data resources behind institutional firewalls.

The privacy rights of both resource providers and users must be ensured. For example, to operate efficiently, Grid applications have to automatically record information about which data were accessed and by whom, but users may wish to keep this information confidential for a variety of reasons. Some security and privacy safeguards are already integrated into Grid projects, but there is a need for more co-ordination and consultation at the international level, in order to develop effective, widely-accepted principles, standards, and procedures. Lack of these can inhibit participation in Grid projects, utilisation of Grids, and the interoperation of independent systems.

Finding F: Providing metadata for advanced Grid applications

One of most potentially useful features of advanced future Grids is their ability to automatically seek out and access the most appropriate scientific data for solving a given problem or running a given application. In practice, this depends on the existence of an agreed terminology ("meta-data"), glossary ("ontology") and annotations to accompany the data itself. This includes such information as the conditions under which the data was gathered, the standards/accuracy/reliability/calibrations/instruments involved, linkages to other data or information, intellectual property rights (IPR) or human information (if applicable), etc. When data is to be shared outside the small circle of the researchers who created it, it must be accompanied by additional information to allow it to be utilised by others but, at present, there are few incentives (voluntary or mandatory) for researchers to invest the time and effort needed for generating meta-data, ontology, or annotation. This is understandable, since the amount of work involved can be considerable. There is a need for more analysis and reflection about international meta-data standards, ontology standards, procedures, and incentives.

Finding G: Acknowledging Grid computing as a research area in itself

As discussed above, there are good reasons for scientists and funding agencies to support standardisation and convergence in Grid designs and implementations. At the same time, however, Grid development needs support as a research topic in its own right. There are many research challenges in e-Science, linked to the inherently distributed and heterogeneous character of the hardware and software. For historical reasons, the development of software for Grids has been largely ad hoc and, in some cases, has not been based on the best software engineering techniques or practices. As a result, debugging an application in the Grid environment can be a major challenge. When a Grid application does not work, software developers need to go through a very large number of modules to track down the errors. If the right tools were available, debugging could take place in situ, while the application is actually running on many different computers and operating systems. Another challenge is linked to deploying software that has been developed. Currently the best way to do so is to deploy the software on each machine using perhaps a different operating system (compiled into the machine code of the host machine) and then to run the application in a distributed mode. This is time consuming and error prone. Ideally it would be possible to develop an application in some kind of universal programming environment, without having to know in advance which machines it might need to run on. As a third example, it is a challenging task to "marshal" the portions of software applications running on different machines, and to "synchronise" their execution, so that the user can "harvest" the results at some location. If an application requires dedicated time on the various machines, this is quite a challenging task to arrange. In the data/information management area, it is challenging to know "what data is to be provided to whom, and who should be granted access to do specified tasks". Such matters take on a different dimension of complexity in the distributed and heterogeneous Grid environment. Investments should be made in experimental architectures, human-computer interfaces, and in innovative applications (taking care, however, not to duplicate work that has already been done). Grid research is an empirical science and, occasionally, large-scale tests need to be carried out, requiring significant computer, personnel and financial resources.

Finding H: Global sharing of the benefits of Grids

Grids can provide access to vast scientific and computing resources with only a modest investment in a local infrastructure (a minimal useful installation would consist of an Internet-linked high-performance workstation). The potential benefits to developing countries are considerable, since scientists would be able to join international collaborations based on their potential intellectual contributions alone. Thus, for example, it is already foreseen that elementary particle physicists in developing countries will be able to fully participate in the operation and exploitation of the Large Hadron Collider experiments at CERN (which is scheduled to begin operations in 2007). After it is completed in 2007, the LHC will generate 15 petabytes of data per annum[8], servicing 5000 research scientists in 500 research organisations or universities around the world. Such global-scale collaboration among researchers will be enabled by the Grid. Similar collaboration opportunities are emerging in other data-intensive domains such as astronomy, bioinformatics, the earth sciences and the social sciences.

A high-speed network connection is a prerequisite for participation in Grid-based collaborations, but many developing countries lag behind in this domain. In some cases, the principal obstacle is the so-called "last-mile" connection between an existing high-speed national hub and the location of the specific university, laboratory, or institute. Another common obstacle is the high cost of local telecommunication connections, caused by national pricing structures that are not adapted to intensive computational usage. Unfortunately, solutions to pricing problems touch on politically sensitive issues of government oversight of telecommunications companies (for example, deregulation). These matters are usually outside the purview of science administrations.

5. Recommendations

Recommendation 1:

In view of their significance for the future of the scientific enterprise (and to the public and private sectors in general) Grids deserve to be treated as research infrastructures in their own right, comparable in scope and importance to other big undertakings such as high intensity X-ray sources, large optical and radio telescopes, or genomic databases. As a critical research tool, Grids should be assigned the resources and funding for assuring robustness, accessibility and reliability that are typical of advanced research infrastructures. Grids can serve many users and communities, and are not just add-ons to individual scientific projects. Accordingly, governments should consider whether they need to modify or create institutional and organisational arrangements to ensure that Grids benefit from the correct prioritisation, planning, funding and oversight mechanisms. Governments should also consider taking steps to strengthen the international mechanisms for co-operation and co-ordination at the scientific, commercial and intergovernmental levels.

Individual research funding agencies should review their grant-awarding procedures to determine whether they are optimised for taking advantage of the special features and benefits offered by Grids. Whenever appropriate, agencies should actively encourage and promote the use of Grids, and discourage the creation of redundant, stand-alone, idiosyncratic computing systems.

Agencies should promote the culture of sharing resources, data and results. They should promote "win-win" solutions, in which all agencies worldwide contribute to the Grid-linked ensemble of computers, software and data, at the same time as they take advantage of the contributions of others.

[8] A petabyte is 10^{15} (one million billion) bytes. The term was once used to denote 2^{50} bytes, a slightly bigger number.

Recommendation 2:

A number of important Grid-related issues need to be addressed in a strategic, systematic, organised, international manner, with the participation of all of the stakeholders: funding agency officials, Grid architects, implementers, and users from the scientific, academic and industrial communities. In a 2.5-day meeting, OECD workshop participants could do no more than identify the issues and signal the need for a more concerted effort to address them. Venues are needed at both the scientific/technological and inter-agency levels, where the problems can be tackled in an open and authoritative way.

At the scientific/technical level, the Global Grid Forum (GGF) has established itself as a dynamic, community-based ("bottom-up") self-organising framework where many of the technical issues are already addressed. The Enterprise Grid Alliance (EGA) is a parallel organisation that brings together interested commercial/industrial entities to address the problems and challenges of the for-profit sector.

To properly carry on with its community-based work in the non-profit academic and research sectors, GGF needs to be put on a sounder financial footing. Accordingly, it is suggested that interested parties consider making a voluntary financial contribution to GGF. The GGF, in turn, should establish a set of priorities and action plans that would allow it to interact more effectively with the funding agencies.

There may be a need for a new, parallel consultative mechanism that is led by funding agencies on a more formally organised and action-oriented basis. Such an inter-funding agency mechanism would need to have links to inter-governmental organisations (for example, OECD) or processes (for example, G8). It would presumably include representatives from the Global Grid Forum, industry, business, and academia. If there is sufficient interest from agencies, further discussions on this matter could be held under the auspices of the OECD Global Science Forum. There may also be a need for specific targeted workshops, for example, on legal, intellectual property rights, or business models related to Grids.

Recommendation 3:

Consideration should be given to the creation of new mechanisms (or the strengthening of existing ones) to facilitate access to Grids for researchers and research organisations in developing countries, plus other appropriate measures to broaden international participation in Grid projects. Telecommunications policies and regulations could be reviewed and, if appropriate, modified to facilitate access to high-speed computer networks in developing countries.

OECD Global Science Forum

WORKSHOP ON GRIDS AND BASIC RESEARCH PROGRAMMES

September 25-27, 2005
Stamford Plaza Hotel Double Bay
Sydney, Australia

PROGRAMME

<u>Sunday, 25 September</u>

Session 0 Introduction to the Workshop

Session 1 Grids for Basic Research and Beyond

1A Essential Features of the Grid

1B Outlook for Research and Beyond

<u>Monday, 26 September</u>

Session 1 cont.

1C Grids for Development and Capacity Building

Session 2 Grids for Basic Research and Beyond

2A Access/Authentication/Authorisation/Accounting

2B Interoperability of Grid Systems and Projects

2C Towards Service and Semantic Grids

Session 3 Policy Challenges

3A Physical Infrastructure and Cost-Payment Issues

<u>Tuesday, 27 September</u>

Session 3 cont.

3B The Grid Development Process

3C Grid Implementation

3D Data Issues

Session 4 Future Directions/ Findings and Conclusions of the Workshop

OECD Global Science Forum

WORKSHOP ON GRIDS AND BASIC RESEARCH PROGRAMMES
September 25-27, 2005

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