

e-Research Coordinating Committee

Chair: Dr Mike Sargent AM

An Australian e-Research Strategy and Implementation Framework

**Final Report of the e-Research Coordinating Committee
to
the Minister for Education, Science and Training and
the Minister for Communications, Information Technology
and the Arts**

12 April 2006

*A joint initiative of the Department of Education, Science and Training and
the Department of Communications, Information Technology and the Arts*



Australian Government

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VISION

Australian researchers will enhance their contribution to world-class research endeavours and outcomes, through the use of advanced and innovative information and communications technologies.

The vision encourages researchers to participate in the transformation process being enabled by ICT, as it offers the power to undertake research on a scope previously unattainable, to work collaboratively and globally in a way not previously possible, and to improve existing research.

The transformation brought about by ICT also extends and broadens the impact of research, by making its outputs more discoverable and useable by other researchers, and by making its benefits more available to industry, governments and the wider community.

EXPECTED OUTCOMES

The e-Research Strategic Framework outlined in this report is designed to be implemented over a period of five years. It is expected that the outcomes of implementing this Framework will be:

Australian researchers will be world leaders in the use of advanced and innovative information and communications technologies, to achieve internationally recognised, high quality research outcomes across Australia's national research priorities;

Australian researchers will be able to access data, instruments, computing capability and to collaborate with each other, through advanced ICT, enabling them to engage readily in collaborative research and contribute significantly to the solution of major national and international research challenges;

Australian researchers will have the necessary education, training and skills, and support from ICT and information management specialists, to use advanced ICT efficiently and effectively;

The implementation of e-Research capabilities across the Australian research sector will provide a leading influence on the uptake and enhancement of such technologies by Australian business and industry; and

The Australian community and economy will benefit from the advanced capability enabled by e-Research.

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Executive Summary

What is e-Research and why is it important?

Just as in other facets of life, information and communication technologies (ICT) are radically transforming the way research communities across the world are operating. Distributed high-performance computing, digital data resources and high speed communications are just some of the developments improving the capacity of researchers to interact with their colleagues and share data worldwide in ways previously un-heard of.

These ‘e-Research’ capabilities are enabling researchers in fields as diverse as medicine, genetics, chemistry, education, linguistics and finance to achieve world class research outcomes and to disseminate knowledge gained from research through the use of advanced ICT. In fact, e-Research has the potential to increase the efficiency and effectiveness of research endeavours across all disciplines. Greater interactivity between researchers and an increased ability to access research outputs will benefit industry, governments and the Australian community as a whole.

Recent research has highlighted the strong role of ICT in Australia’s productivity growth over the past 20 years. The increasingly intensive use of information and knowledge is driving value creation, productivity, and economic growth. With the shift towards a more knowledge intensive economy, the widespread use of e-Research is fundamental to Australia’s ability to remain internationally competitive.

In 2004, the Australian Government recognised that a cohesive and coordinated approach to accelerate the uptake of e-Research by the research community was needed if Australia’s research strengths were to remain internationally relevant and competitive. On 19 September 2004, in *Information Technology: Connecting an Innovative Australia*, the Coalition made an election commitment to implement a coordinating structure for e-Research, modelled on the UK e-Science Programme.

In April 2005, the e-Research Coordinating Committee was established jointly by the Minister for Education, Science and Technology and the Minister for Communications, Information Technology and the Arts to provide expert advice to the Government about developing Australia’s e-Research capacity. In December 2005, an interim report of the e-Research Coordinating Committee was accepted by the Government as the basis for further work to develop an e-Research implementation strategy. This report is the culmination of the e-Research Coordinating Committee’s work and proposes the implementation of a strategic framework and activities to accelerate the development of Australia’s e-Research capabilities.

What are the consequences of doing nothing?

While there have been individual advances in the development and use of e-Research across the Australian research sector, change is happening slowly compared with other nations. Overseas governments, particularly in the UK, Europe, North America and East Asia, are investing heavily in research infrastructure and are developing e-Research skills and tools to facilitate more productive use of the infrastructure and realise benefits from international collaborative research.

Through the *Backing Australia’s Ability* innovation statements, the Australian Government is investing over \$8.3 billion in research infrastructure and research over the period 2001-02 to 2010-11. In particular, the \$542 million investment in research infrastructure under the National Collaborative Research Infrastructure Strategy (NCRIS) will result in distributed infrastructure capable of supporting significant interactivity by a highly distributed research community. In

addition, the Government is investing over \$1 billion in improving broadband infrastructure across the nation, through *Connect Australia*, announced in August 2005. The National Broadband Strategy, implemented in 2003, provides a coordinated approach to ensure that government investment in broadband supports regional priorities and the specific needs of key sectors.

A failure to similarly stimulate and coordinate the development and use of e-Research capabilities in Australia will result in:

- a less than optimal return on the Government's substantial investments in infrastructure;
- Australian researchers and Australian research becoming less internationally competitive and relevant;
- the inability of Australian researchers to participate in those emerging fields of research that are only enabled by e-Research;
- the failure of industry to realise the benefits of improved collaboration with researchers and access to research outputs and innovation; and
- a failure to realise the potentially significant economic and social returns for the Australian community as a whole.

This will ultimately impact on economic growth and the Government's objective to capture a larger share of the global benefits of the information economy, for the benefits of all Australians.

The e-Research Strategic Framework

This report addresses the key issues identified in the e-Research Coordinating Committee Interim Report, and proposes a strategic framework of activities to accelerate the uptake of e-Research capabilities over a five year period, in order to bring forward benefits and strategically position Australian research capability internationally.

Key issues addressed are:

- the need for leadership to drive cultural change;
- fostering engagement, participation and cooperation;
- research, development and deployment of ICT solutions for e-Research;
- skills acquisition;
- support for researchers through a national e-Research Centre;
- access, authentication and authorisation;
- support for the physical resources, software and services that enable e-Research activities (otherwise known as the e-Research 'fabric');
- data management and accessible databases; and
- coordination.

While the proposed e-Research strategic framework specifically addresses the needs of the research community, many of these issues are common to other sectors of the economy. In responding to these emerging issues, the Government has already developed policies in areas such as e-Commerce, e-Health and e-Government. The proposed strategic development of e-Research capabilities will inevitably enhance these initiatives, but should be implemented in a way that takes account of policy directions and technological developments in other sectors.

The e-Research strategic framework is primarily about stimulating and coordinating change in order to improve research outcomes. As a result, the strategic interventions proposed are

designed to accelerate change at a critical point in the e-Research adoption curve and are not expected to be required long-term.

A vision for e-Research in Australia

The vision for e-Research is that:

Australian researchers will enhance their contribution to world-class research endeavours and outcomes, through the use of advanced and innovative information and communications technologies.

The vision encourages researchers to participate in the technological revolution that offers the power to undertake research on a scope previously unattainable – to work collaboratively and globally and improve their research as a result.

The transformation driven by ICT also has the potential to extend the impact of research, by making it easier for other researchers, industry, governments and the wider community to locate and use the results.

The e-Research Strategic Framework outlined in this report is intended to be implemented over a period of five years. The outcomes expected are:

- Australian researchers will be world leaders in the use of advanced and innovative ICT to achieve internationally recognised, high quality research outcomes across Australia's national research priorities;
- Australian researchers will have access to data, instruments, computing capability and be able to collaborate with each other, through advanced ICT. This will enable them to engage more readily in collaborative research and contribute to the solution of major national and international research challenges;
- Australian researchers will have the necessary education, training and support from ICT and information management specialists, empowering them to use advanced ICT efficiently and effectively;
- The implementation of e-Research capabilities across the Australian research sector will provide a leading influence, encouraging the take-up and further development of such technologies by Australian industry and business; and
- The benefits of a more effective and competitive research sector will flow on to the Australian economy and community as a whole.

RECOMMENDATION

1. The Committee recommends that Ministers note that the implementation of the e-Research Strategic Framework is critical to the success of e-Research in Australia, and agree to implement the strategic plan of action outlined in this report.

The need for leadership

Progressing the e-Research agenda is as much about people as it is about technology, because e-Research is challenging existing research practices and cultures. There is a need for strong leadership to articulate the vision and engage key players in taking the strategy forward in a coordinated manner.

Overseas experience, particularly in the UK, strongly suggests that success in engaging the research community in e-Research is associated with the appointment of a 'champion', a well-

respected member of the research community, recognised by government, the research sector and business as the visible face of e-Research.

It is recommended that the Government appoint an e-Research Leader to facilitate the e-Research reforms and to champion the e-Research vision. It is also recommended that the Government appoint an e-Research Committee to steer the implementation of the e-Research Strategic Framework, in consultation with the research sector and other stakeholders. The e-Research Leader should chair the e-Research Committee.

RECOMMENDATION

2. The Committee recommends that Ministers appoint an e-Research Leader to champion the e-Research agenda within government and the research community, be the visible face of e-Research, and to chair an e-Research Committee, established to oversee the implementation of the e-Research strategies proposed in this Report.

Building on the current research base

The take-up of e-Research will be reliant on the availability of fully functional, scaleable applications, user interfaces and data management and administrative services, defined collectively as ‘operational services’. To date, the Australian Government has invested in a range of innovative projects under the auspices of the Australian Research Information Infrastructure Committee (ARIIC), the Advanced Networks Programme (ANP), the Australian Research Council (ARC), the National Health and Medical Research Council (NH&MRC), the CSIRO and other organisations. While the outcomes of these projects are informing the development of operational services, further research and development to support Australian e-Research capabilities is essential. In particular, Australian participation in international standards-setting should be encouraged, and the Committee recommends that funds be dedicated to supporting these activities.

RECOMMENDATIONS

The Committee recommends that:

3. Ministers establish a strategic Research, Development and Deployment programme to support e-Research in Australia, to be administered by the e-Research Committee and conducted in the international and commercial context; and
4. That this also includes further funding for existing initiatives developed under the Systemic Infrastructure Initiative and the Building IT Strengths initiative, in order to deploy fully functional applications and tools to enable Australian e-Research.

Skills acquisition

Many of the technologies that support e-Research are at the cutting edge of developments world wide. Although Australia does have world-class leaders in some of these technologies, there is a nation-wide lack of skills to support the rapid take-up of e-Research, and. recommendations focus on developing:

- practical skills for researchers who want to use e-Research applications;
- skilled professionals who can operate across research domains to help researchers use e-Research applications; and
- experts in ICT and information management who are capable of undertaking research and developing new e-Research platforms and applications.

There is a need for education and research opportunities to equip highly motivated students to choose careers in the technologies which support e-Research. A number of Australian universities have already introduced course modules that focus on aspects of e-Research into their undergraduate degree programmes. Universities should be encouraged to introduce conversion courses in this field and to provide opportunities in this area as part of the professional development of their staff.

To complement this, the Committee recommends funding a series of one- and three-year scholarships and awards to provide a strategic flow of suitably qualified people to fill the skills gap over the five-year funding period. Recommended are:

- one-year Honours Scholarships, which support students undertaking projects that incorporate e-Research problems; and
- three-year Post-Graduate Awards, with a particular focus on e-Research. .

To complete the picture, the Committee recommends that a small number of qualified professionals be employed to conduct outreach programs and provide technical support via an e-Research Centre. It is recommended that the e-Research Centre have multiple nodes, strategically located in regions of research intensity.

RECOMMENDATIONS

5. The Committee endorses undergraduate cross-disciplinary ICT electives and subjects at the undergraduate level that will prepare graduates for career pathways to e-Research.

The Committee recommends that:

6. Ministers agree to the establishment of a five-year programme of one-year e-Research Honours Scholarships, to be administered through the proposed e-Research Centre, to support honours students to undertake projects in e-Research enabling methodologies and cross-disciplinary applications of e-Research;
7. Ministers agree to the establishment of a five-year programme of three-year e-Research Postgraduate Scholarships to support students undertaking research training in e-Research capabilities at the Ph.D. level. This programme should be coordinated through the proposed e-Research Centre; and
8. Ministers encourage the introduction by institutions of formal incentives, recognition and reward mechanisms for the skilled e-Research professionals who support and provide expertise to researchers, and to encourage academics to invest time and expertise to develop cross-disciplinary projects and courses to train a new generation of e-Researchers.

Skills transfer and support for researchers through an e-Research Centre

In the UK, the success of the government funded e-Science initiative was due in large part to the establishment of several e-Science centres which provided a focal point for research, development, support and outreach into e-Science.

Similarly, the Committee recommends the establishment of a national e-Research Centre comprised of several nodes located in regions of research intensity. Their primary role would be to act as change agents locally and nationally to embed e-Research methodologies in research practices. The nodes would provide outreach programmes and support services for researchers and serve a critical role in skills development, skills transfer and the development and deployment of e-Research applications. This is likely to stimulate additional interest and

investment on the part of State and Territory governments and local institutions to support the e-Research nodes over and above the contribution of the Australian Government, through co-investment or the provision of facilities, personnel or infrastructure. This will significantly increase the functionality, relevance and support role of the local nodes.

Leadership in the nodes of the proposed e-Research Centre would be enabled through a programme of five-year e-Research Pathfinder Fellowships, to support a leading e-Research exponent to lead the activities of each node. The e-Research Centre would also coordinate, in conjunction with universities, a programme of three-year e-Research Postdoctoral Fellowships to facilitate skills transfer into university research communities in various disciplines.

RECOMMENDATIONS

The Committee recommends that:

9. Ministers establish an e-Research Centre, consisting of a distributed set of nodes in regions of research concentration, and reporting to the e-Research Committee, for a period of five years, in order to facilitate the transformation of Australian research through the transfer of e-Research methodologies to the research community;
10. Ministers introduce a programme of merit-based, high-profile, e-Research Pathfinder Fellowships, each of five years' duration, to be administered through the e-Research Committee;
11. Ministers agree to the establishment of a five-year programme of high-profile e-Research Postdoctoral Fellowships to support research, development and deployment of e-Research capabilities and methods to be administered through the e-Research Committee; and
12. Ministers support a targeted outreach programme that will raise awareness in the Australian research community of the benefits of ICT and will encourage the transition to e-Research, to be administered through the e-Research Committee.

Access for Researchers

A key enabler for e-Research in Australia is to give researchers seamless access to resources, including each other. Resources are distributed in various areas of Australia and overseas and include:

- digital data repositories;
- scientific facilities, instruments and sensors;
- computational facilities; and
- high-speed telecommunications networks.

The Committee has identified the need to put in place a national, robust identity provision solution that will allow researchers' identity to be authenticated, and their access authorised, to distributed resources via a single sign-on system.

It is important to researchers, students and the public that research results be accessible as early as possible in the research cycle to better inform their research endeavours and taking into account confidentiality requirements.

The Australian Government is committed to developing a Research Accessibility Framework for publicly funded research to ensure that information about research and how to access it is available to researchers and the wider community.

Implementation of the Committee's recommendations will address e-Research capability issues, which in turn will inform the development of the Accessibility Framework.

The report identifies the need to pursue a nationally coordinated approach to the issues of access and authorisation. This will be particularly important in developing access regimes for research infrastructure funded under NCRIS.

RECOMMENDATIONS:

The Committee recommends that:

13. Ministers note that the interrelated issues of security, access, authentication and authorisation are important in the context of the e-Research Strategic Framework; and
14. Ministers agree to fund, within that Framework, the development by the e-Research Committee of a set of national guidelines for authentication and authorisation trust federations, building on the work of the *Meta Access Management System* Project and the *e-Security Framework for Researchers* Project funded by the Department of Education, Science and Training.

Support for the research fabric

The 'e-Research fabric' refers to the physical resources, software and services that link, or are linked to enable, e-Research activities. They include broadband networks, middleware services, computing capability, scientific instruments, and digital data repositories. Linking the physical resources can significantly add capacity to the e-Research infrastructure.

Australia's research and education telecommunications networks, particularly the Australian Research and Education Network (AREN) provide high bandwidth links to support e-Research, having been enhanced by substantial government investment over the past few years.

However, there will be an ongoing need to extend broadband capability to more remote institutions in the network and to other key sources of data and resources, including research agencies, cultural institutions and strategically important international partners.

The availability of high performance computing capability is critical to support a number of e-Research applications. As a result of substantial Government investments in recent years, the Australian Partnership for Advanced Computing (APAC), a number of universities and publicly funded research agencies provide high performance computing facilities in various parts of Australia. Many of these computing facilities are networked and therefore can provide distributed computing capability. In terms of implementing the e-Research agenda, it is important that as many such facilities as possible be available to service researchers' increasingly advanced computing needs.

Australia also needs to develop an underlying fabric (e.g. facilities, sensor networks) that facilitates capture, storage and subsequent access to research data by the research community, and by the wider community where appropriate, whilst addressing security issues.

Development of the underlying fabric will need to address the following categories of issues:

- policies;
- technical issues;
- security issues;
- data discovery issues;
- service delivery; and

- data quality assurance.

The full utilisation of advanced ICT infrastructure is increasingly dependent on computer software, termed middleware, that links the ICT resources that users need. Middleware provides the common set of services and tools that allows researchers and applications to treat the data repositories, computing, and other disparate resources as if they were one large virtual facility.

While there has been considerable progress in middleware development and deployment both within Australia and overseas, the Committee recommends that arrangements should be put in place to reduce duplication of effort and deliver widespread efficiencies. This could be achieved through the adoption of a common middleware strategy, developed in the context of Australian and international standards.

RECOMMENDATIONS

The Committee recommends that:

15. The e-Research Committee liaise with the NCRIS Committee to recommend to Ministers a strategy for developing a national data architecture, in consultation with the broad community of researchers; and
16. The e-Research Committee oversees the adoption of common middleware and service standards, taking into account Australian and international developments, in the development and provision of operational services, such as middleware repository services, to the Australian research sector.

Managing Data

Managing data effectively is essential to support the full cycle of research endeavour, from research concept formulation and scoping to the research activity itself, to dissemination of the results of research.

The Committee identified the data management needs of researchers as being:

- data collection and generation;
- data storage and the physical management of stored data;
- evolution of standards and protocols to facilitate the storage, use and interpretation of data;
- access to data; and
- long term archival and preservation of data and policy for retaining and discarding of data.

Research domains globally are generating unprecedented quantities of data and the issue of data management is increasingly a critical one. There is need to balance the likely accessibility needs of researchers to data against the likely costs to the research sector and the wider community of long term data retention.

The Committee recommends that the Government convenes a working group to develop an Australian Research Data Strategy. Such a strategy must be considered in the international research context, given that Australia's research sector will need to align with prevalent international data management standards in order to engage fully with overseas researchers into the future.

The Committee also received input from a number of organisations and individuals seeking support for a national strategy and investment programme to digitise existing non-digital institutional and national data resources, including books, periodicals, documents, artworks, sound recordings, official records, folios, and research papers.

The Committee believes that such a programme is warranted, and will have broad research and community benefits. However, such a digitalisation programme extends beyond the focus of the e-Research Coordinating Committee and the Committee does not provide a detailed recommendation on this issue. The report recommends that the Government give consideration to establishing a process to investigate the needs of the Australian community for digitisation of existing information resources, and to consider arguments for a National Digitisation Strategy in conjunction with the proposed Australian Research Data Strategy.

RECOMMENDATIONS:

The Committee recommends that:

17. The Government convenes a working group to develop an Australian Research Data Strategy that will support a standardised national approach to the management of data collected, generated, and used by the Australian research community. The Working Group should include representatives of the e-Research Committee and will liaise with peak bodies associated with research and data collection and management, including the National Collaborative Research Infrastructure Strategy Committee; and
18. Ministers establish a process to investigate and assess the needs of the Australian community for digitisation of existing information resources.

Coordination, Oversight and Resources

The report recommends that an e-Research Committee be established to replace the existing Coordinating Committee in order to implement the e-Research Strategic Framework over a period of five years. The new Committee would provide the strategic direction, drive and engagement and coordination of effort of research groups involved in e-Research. It would also take account of existing Systemic Infrastructure Initiative (SII) advisory structures and develop a close working relationship with the NCRIS Committee and its facilitators.

It is envisaged that the Committee be established at a high level and answerable to the Minister for Education, Science and Training and the Minister for Communications, Information Technology and the Arts, and be chaired by the national e-Research Leader.

The Committee has estimated the cost of implementing the programmes recommended under the e-Research Strategic Framework to be in the order of \$30 million per year, over five years. There are likely to be additional establishment and administrative costs, some of which could be met through co-investment on the part of universities, research institutes or state or territory governments. Given the Australian Government's \$8.3 billion investment in research and research infrastructure over 2001-02 to 2010-11, this relatively modest investment in e-Research is seen as prudent and likely to improve the return significantly on the Government's substantial investment in research and research infrastructure.

RECOMMENDATION

19. The Committee recommends that Ministers establish an e-Research Committee, chaired by the national e-Research Leader, to oversee the implementation of the e-Research Strategic Framework. The Committee will promote coordination of effort and set directions and objectives to increase adoption of e-Research methodologies in Australia, in consultation with the research sector and the community of stakeholders.

1 The Critical Importance of e-Research

1.1 e-Research

The term 'e-Research' encapsulates research activities that use a spectrum of advanced ICT capabilities and embraces new research methodologies emerging from increasing access to:

- broadband communications networks, research instruments and facilities, sensor networks, data repositories with their associated data standards and management tools, and high performance computing resources;
- software and infrastructure services that enable a trust and sharing relationship to be established between researchers and the wide variety of data repositories, computers, systems and networks on which they depend; and
- application and discipline-specific tools such as graphics intensive visualisation, simulation software, and interaction tools that provide the human interface allowing researchers to interact with each other and with their instruments, computational facilities and data resources.

e-Research capabilities serve to advance and augment, rather than replace traditional research methodologies. There is a growing dependence on the following e-Research capabilities to:

- discover knowledge, whether held in digital or physical forms;
- access data as well as the software services that are being made available to manipulate or analyse this data;
- synthesise, curate and disseminate new knowledge efficiently; and
- facilitate interactivity and research collaboration, allowing researchers to work seamlessly from desk-to-desk within and between organisations.

The main factors that enable researchers to increase their use of ICT are:

- their awareness of the full potential of ICT to enhance their research;
- the availability of an interconnected fabric of underlying shared service resources that facilitate access to diverse data sets, collaboration and interoperability, regardless of the discipline of the researcher, or computer platform being used;
- the ease of access to, and expert support of, ICT resources; and
- the skills and abilities of the researchers themselves, to make full use of the ICT services and facilities at their disposal.

The amount and range of benefits from greater use of e-Research methodologies will vary between researchers and disciplines, according to their needs, awareness and skills, and the availability of the necessary support, expertise and physical resources.

1.2 Research productivity

Australia's ability to produce and apply knowledge effectively is becoming ever more critical in determining its economic, social and environmental success. For this reason, the Australian Government is making large investments in research and innovation. Through Backing Australia's Ability (announced originally in 2001 and extended in 2004 through Backing

Australia's Ability – Building our Future through Science and Innovation), the Government has committed \$8.3 billion over 10 years to support research and its underpinning infrastructure, commercialisation of research outcomes and skills development. Of the total, more than \$1 billion has been committed to improve research infrastructure. Overall, direct Australian Government support for research to universities and publicly funded research agencies (PFRAs) now stands at over \$1 billion per year. e-Research has a major role to play in ensuring that the best possible returns are realised from these investments in a changing environment.

e-Research represents a strategic imperative if Australia is to remain competitive in research and ultimately benefit economically. e-Research is revolutionising researchers' ability to collect, generate, share, analyse, store and retrieve information i.e. to conduct e-Research. Crucially, it also provides platforms enabling increased levels of collaboration – not only within the research community (across institutional, disciplinary and national boundaries) but also between the research community and users of research in the business and wider communities. This is critically important given the great distances over which our research resources are dispersed within Australia, and between Australia and other countries.

e-Research also opens entirely new research vistas, organisational models and collaborations that were previously not possible using traditional research methods. Researchers in a variety of domains, now and in the future, can benefit from new capabilities to interpret, correlate, and track diverse data stored in federated repositories. High performance and distributed computers, advanced algorithms and numerical simulations allow researchers to model complex systems ever more realistically. High bandwidth research and education networks established around Australia enable affordable access and transport of information, including access to major research instruments and facilities. Research communities can communicate, visualise and share data with collaborators in real time.

While information and communications technologies are already transforming many areas of research, a great deal remains to be done to fully capture their potential to enhance the quantity, quality and productivity of Australia's research effort.

Evidence from the Department of Communications, Information Technology and the Arts shows that ICT is making a much more significant contribution to Australia's productivity growth than was previously believed. For example, technology has contributed between up to 78 per cent of productivity growth in services industries over the 17 years to 2001-02. Because of its pervasive character, ICT continues to drive significant social and organisational change. As ICT evolves at a rapid pace, we can expect this contribution to continue well into the future. Thus ICT has the potential to make further significant contributions to economic and social enhancement, thus improving the quality of life in Australia.

On a global scale, the level of investment in ICT enablement of research in the United Kingdom, United States of America, Europe and Canada is beginning to pay dividends. In the United Kingdom, £250 million has been invested in the e-Science programme over the past 5 years and the programme has drawn further significant investment from corporations such as IBM, Microsoft and Oracle. In the Asia Pacific region, the governments of Japan, Korea, Taiwan and China are strongly committed to finance their e-Research frameworks. Countries investing in e-Research capabilities are increasingly participating in collaborative research into the grand challenges, for example, in geophysics, climatology, medicine, genetics, epidemiology, archaeology and anthropology.

The Australian Government has already implemented significant ICT enabling agendas for various sectors of the economy under its e-Commerce, e-Government, e-Security, e-Health and e-Learning initiatives. It is imperative that the e-Research agenda now be taken forward quickly, otherwise development will take place inefficiently in a piecemeal fashion and Australian

researchers will be left behind their counterparts in other countries. The e-Research agenda aims to overcome disciplinary silos by enabling collaborative research across disciplines and within disciplines across countries, thereby achieving a more competitive and innovative Australian research community.

1.3 Industry developments

ICT is revolutionising the way in which industry operates. Multinational companies have secured significant efficiency gains by linking their global operations through advanced ICT. More generally, large and small companies have adopted business practices using advanced ICT, for example business to business transactions and sales and marketing to the public.

New developments in ICT, and in the systems and policies regulating its use across organisational boundaries, will improve access to e-Research capabilities by researchers in the private sector. Participation in collaborative research projects with public sector researchers will encourage use of e-Research methodologies. The need for development of e-Research capabilities will also provide opportunities for ICT companies to deploy new systems and tools to meet researchers' needs.

The e-Research agenda also has a role to play in the subsequent uptake by industries of leading edge technologies and systems that the research sector adopts. Many of the e-Research capabilities in areas such as collaborative research tools, access regimes, data management etc, will be adopted by industry over the medium term. Indeed e-Research has significant potential to revolutionise corporate ICT systems. Significantly, it will facilitate small and medium companies to gain access to facilities and collaborate with researchers in the public sector, which they will otherwise find difficult to do, due to invisible barriers placed by organisational boundaries. e-Research facilitates the seamless and trusted access of researchers in small and medium companies to facilities in the public sector.

1.4 Australian Government commitment

In September 2004, the Government made an election commitment to implement a coordinated structure for e-Research, modelled on the UK e-Science programme, to capitalise on the potential of collaboration at both the national and international levels, and on the substantial investments made in research infrastructure. The Government established the e-Research Coordinating Committee in April 2005 charged with the responsibility to establish a strategy and coordinate support for research utilising advanced ICT.

The Committee's Interim Report of 30 September 2005 identified the key issues in terms of what researchers need in order to realise their full potential in research by using advanced ICT. Those needs were based on the outcomes of extensive consultations and submissions received from across Australia from stakeholders including individual researchers, research performing organisations, research funding organisations, Australian Government Departments and State and Territory Governments.

The Committee's Report recognised that the value and successful uptake of e-Research methodologies depends on the awareness and abilities of people, as much as on the quality and intuitiveness of the methodologies themselves. Key issues include, for example, the preparedness of different data owners to adopt common standards to facilitate sharing of data between data systems; the quality and availability of expert technical staff who can show researchers how to make the best possible use of the power that e-Research makes available to them; the recognition and reward mechanisms for such staff; and the role played by policies at both the institutional and governmental levels in encouraging (or inhibiting) e-Research uptake.

The Committee's Interim Report proposed that, only by a national coordination of efforts, addressing all the components raised in its Interim Report in an e-Research strategic framework, can researchers and research projects realise their full potential.

The Interim Report was accepted by Government as the basis for further work to develop this e-Research Strategic Framework.

The Committee considers that, only by a concerted, strongly-directed, intervention-based strategy and national cooperation will the critical mass be achieved to more fully enable Australian researchers with e-Research capabilities.

1.5 Investments to date

The Australian Government has already invested heavily in the communications infrastructure necessary to support e-Research. The Systemic Infrastructure Initiative (SII) supported under *Backing Australia's Ability* provides funding for strategic physical and information infrastructure going forward. In addition, the Government is investing over \$1 billion in improving broadband infrastructure across the nation, through Connect Australia, announced in August 2005. The National Broadband Strategy, implemented in 2003, provides a coordinated approach to ensure that government investment in broadband supports regional priorities and the specific needs of key sectors. The e-Research initiative is aimed at ensuring that Australia gains the best value from these investments.

The national research infrastructure that the Government has been investing in consists of the following key elements:

- a robust high bandwidth telecommunications network, the Australian Research and Education Network (AREN);
- distributed high performance computing capacity, the Australian Partnership for Advanced Computing (APAC);
- accessible digital repositories (research databases, online libraries etc);
- accessible research facilities and large instruments (telescopes etc); and
- agreed standards and specifications to maximise interoperability between networks, computer platforms and applications including middleware (the software glue to assure accessibility etc).

As part of the \$1 billion research infrastructure commitment, \$542 million is currently available under the National Collaborative Research Infrastructure Strategy (NCRIS) over 2004-05 to 2010-11. This will continue to provide researchers with access to major infrastructure while linking infrastructure funding more directly to Australia's National Research Priorities and fostering greater research collaboration and the collaborative use of infrastructure. Whilst significant synergy is shared between NCRIS and e-Research, the major difference is that NCRIS is primarily focused on research infrastructure across a defined number of disciplines to enhance particular research capabilities. The facilitation of e-Research encompasses a wide range of governance and skills issues, to enable wider use of the infrastructural 'platforms for collaboration'. It is likely that some of the findings in this report, e.g. data management issues, access and identity management issues, will be applicable to issues arising and identified by facilitators in the NCRIS themes. The NCRIS and e-Research agendas complement each other and need to be run in parallel.

2 Strategic Framework for e-Research in Australia

2.1 Issues and Strategic Directions

A wide cross-section of the research community, including some members of the international community, provided overwhelming support for the development of an Australian e-Research strategic framework.

The Committee received strong support for the directions set out in the Discussion Paper and subsequent face-to-face consultations, from stakeholders in each state and territory. Stakeholders included State and Territory Governments, universities, publicly funded research institutions, industry and individual researchers. A list of the individuals and bodies that made written submissions is provided in the Appendix to this Report. Submissions identified a range of barriers that impact adversely on the take-up of e-Research methodologies and strongly proposed the need for steps to be taken to remove the barriers. Similar issues were independently identified by participants in the national NCRIS consultation process.

The Committee's Interim Report set out the policy issues pertinent to Australia securing maximum benefit from the use of e-Research techniques; proposed strategic directions which should be pursued; and identified further steps that would allow generation of an implementation plan. The key issues identified by the Report to enable e-Research in Australia were the need for:

- development of three groups of skilled professionals to hasten the adoption of e-Research methodologies, namely, researchers' proficiencies in e-Research, specialist expertise in ICT and information management, and day-to-day ICT operational support;
- adoption of best practice in digital data management, standards and common practices, and resolution of security issues;
- linkage of e-Research resources through advanced ICT;
- changes to organisational structures and cultures;
- increased knowledge by researchers to enable their productive use of e-Research methodologies;
- focus of the existing e-Research expertise on supporting new innovative activities and the growth of e-Research capabilities and skills; and
- recognition of the importance of collaboration in achieving research excellence and the fundamental role of e-Research methodologies in realising that objective.

The Interim Report drew on the above issues to propose broad strategic directions to facilitate faster take-up of e-Research methodologies in Australia. Submissions received in response to the Interim Report generally strongly supported the Committee's proposals and made some further suggestions on particular issues, for example the importance of addressing skills issues through multiple levels in the education and training systems.

This Final Report brings together, and develops further, the findings of the Interim Report into a proposed cohesive implementation strategy that is needed to take the necessary steps to address the identified issues.

2.2 Vision and Goals

Rapid changes in ICT are impacting on research methodologies and collaborative approaches the world over, and Australian researchers need to make the most of the opportunities being offered by these advances or risk being left behind as new research directions unfold. Australia needs a vision and a strategy to move forward.

A vision for e-Research in Australia

Australian researchers will enhance their contribution to world-class research endeavours and outcomes, through the use of advanced and innovative information and communications technologies.

The vision recognises that Australian researchers are currently at the forefront of many fields of research endeavour and intends that they not lose the position for which they have strived so hard.

The vision encourages researchers to participate in the transformation process being enabled by ICT, as it offers the power to undertake research on a scope previously unattainable, to work collaboratively and globally in a way not previously possible, and to improve existing research.

The transformation brought about by ICT also extends and broadens the impact of research, by making its outputs more discoverable and useable by other researchers, and by making its benefits more available to industry, governments and the wider community.

To implement the e-Research agenda, the vision needs to be understood and adopted by all stakeholders.

Goals

Based on the key issues, or the barriers to take-up of e-Research methodologies, identified in the Committee's Interim Report, the Committee believes that the e-Research strategic framework should be informed by the following goals:

- Australian researchers will be world leaders in the use of advanced and innovative information and communications technologies, to achieve internationally recognised, high quality research outcomes across Australia's national research priorities.
- Australian researchers will be able to access data, instruments, computing capability and to collaborate with each other, through advanced ICT, enabling them to engage readily in collaborative research and contribute significantly to the solution of major national and international research challenges;
- Australian researchers will have the necessary education, training and skills, and support from ICT and information management specialists, to use advanced ICT efficiently and effectively;
- The implementation of e-Research capabilities across the Australian research sector will provide a leading influence on the uptake and enhancement of such technologies by Australian business and industry.
- The Australian community and economy will benefit from the advanced capability enabled by e-Research.

2.3 Principles

The e-Research strategic framework should be guided by the following principles:

Australia should realise the maximum possible benefit of national investment in research infrastructure

The Australian Government has invested substantially in a broad range of network and information infrastructure to support researchers. The Government will obtain the best return on its investments by taking steps to enable Australia's researchers to make better use of that infrastructure.

Australian researchers should adopt e-Research methodologies

Australian researchers should be encouraged to take-up e-Research methodologies quickly, and wherever appropriate, through properly structured incentives.

Australian, and some international, research data and facilities should be seamlessly accessible

Australian researchers and others should be able to access data seamlessly, scientific facilities and sensors that are located outside their organisations, including some international resources and data.

Australia's capacity for e-Research should grow and be sustainable

Australia should sustain its e-Research capability in the longer term through the development of a strategic skills base among researchers and their supporters, through broad awareness of the potential of e-Research, and through research and development into strategically important ICT and information management methodologies and facilities.

Australia's e-Research strategy should promote and enable collaboration

National e-Research policy and implementation strategies should enable more collaborative activities amongst researchers, both within and between the public and private sectors, and should facilitate Australia's researchers to engage meaningfully with the international research community.

Australia's e-Research strategy should foster excellence in research and international competitiveness

Australia's e-Research strategy should enable researchers to access the best facilities and services, and to work collaboratively with the best researchers in the most efficient and effective manner, in existing and new fields of research, nationally and internationally.

Australia's research outputs should have maximum impact

Australia's e-Research strategy should encourage the earliest and widest possible dissemination of research outcomes, in appropriate formats and locations, for the benefit of other researchers, governments, industry and the wider community.

The Australian Government should take the lead in implementing e-Research policy in a coordinated, integrated manner

The Australian Government should maximise the benefits of e-Research by taking a leading role in stimulating and enabling stakeholders to work together to develop e-Research capabilities in Australia.

2.4 Moving forward –implementation of the e-Research strategic framework

Australia needs to be more strategic in how it goes about addressing e-Research issues. Currently, there are various researchers, projects and programmes administered by various institutions and agencies that, either directly or indirectly, engage in or support e-Research. Although good progress has been made, there is now an urgent need for arrangements to be put in place that would facilitate a more cohesive, coordinated framework for the various stakeholders to enable formal interaction. The roll out of research infrastructure under NCRIS will provide a further impetus for a cohesive strategy.

This Report presents the core elements for implementation of a cohesive, user-based approach to Australia's development of e-Research capabilities and methodologies, through an e-Research Strategic Framework.

The key elements of the e-Research Strategic Framework, addressed in Sections 3 to 10 of this report are:

- the need for leadership to drive cultural change;
- fostering engagement, participation and cooperation;
- research, development and deployment of ICT solutions for e-Research;
- skills acquisition;
- support for researchers through a national e-Research Centre;
- access, authentication and authorisation;
- support for the e-Research fabric;
- data management and accessible databases; and
- coordination of effort.

Section 10 of this report proposes the overarching coordination arrangements, including a high-level e-Research Committee to ensure that the e-Research Strategic Framework is steered and implemented cohesively and effectively.

The Committee has raised considerably the awareness, engagement and sense of urgency of stakeholders through its widespread consultations during 2005. The momentum gained should not be lost, and the Committee proposes that the implementation strategy should build on that momentum and commence being put in place immediately.

There are already strong indications that some state governments and a number of universities are prepared to co-invest in developing e-Research capabilities.

Use of e-Research methodologies by researchers, in terms of both more widespread and deeper use, will take a number of years to become reasonably pervasive in the research sector. The e-Research Strategic Framework should therefore be implemented over approximately five years, with a review of progress in the fourth year. One part of the strategy, the Accessibility Framework, will enable better access to research outputs. It will need to be put in place in the short term to support the implementation of the Research Quality Framework announced by the Government in May 2004.

The Government should monitor the implementation of the e-Research Strategic Framework and its impact, to guide the continuing implementation, and to evaluate its success. Both quantitative

and qualitative evaluation measures will be needed, so that the achievement of the vision and goals can be assessed.

RECOMMENDATION

1. The Committee recommends that Ministers note that the implementation of the e-Research Strategic Framework is critical to the success of e-Research in Australia, and agree to implement the strategic plan of action outlined in this report.

3 Leadership

3.1 The role of Leadership in e-Research Implementation

The e-Research Strategic Framework will comprise a number of diverse elements that need to be taken forward and coordinated efficiently and effectively. This requires a clear focus and coordination of activity across the broad spectrum of e-Research stakeholders. The implementation strategy will therefore require strong leadership as the catalyst to drive the agenda.

The Australian Government is in the best position to take the lead and work with other stakeholders to provide the focus and scale that is needed to hasten the take-up of e-Research methodologies in order to achieve the e-Research vision and goals. Stakeholders include state and territory governments, universities, publicly funded research institutions, industry and individual researchers.

Championing the e-Research agenda

For the e-Research strategy to be effective, it should be championed at the highest levels of the research community, governments and industry. A champion is needed to focus the leadership of e-Research by articulating the vision and engaging key stakeholders in taking the strategy forward. The appointment of such a person was a critical success factor for the e-Science Initiative in the UK.

The Government should identify a national e-Research Leader who will be the visible ‘face’ of e-Research to the research community and to the other stakeholders. The Leader should be a person who:

- is recognised and highly respected by the research community;
- will shape the culture and dynamics of the e-Research strategy;
- has good communication and people skills and will build people networks, for example on a one-on-one basis with vice-chancellors and by being instrumental in bringing relevant stakeholders together;
- will influence organisations and individuals in the way they perceive and respond to the e-Research agenda;
- understands and is experienced in e-Research; and
- is able to enthuse and inspire a range of ICT and research specialists to carry the agenda forward in their own domains.

Given the broad range of stakeholders, leaders will also need to be identified at the operational level to provide the enthusiasm and drive in implementation:

- within the operational structure, including within state and territory governments, universities, publicly funded research institutions and industry – they will influence these organisations to transform practices and cultural behaviours, and generate enthusiasm for e-Research methodologies;
- within the distributed nodes of the proposed e-Research Centre – these ‘e-Research Pathfinders’ will forge links between stakeholders, driving new solutions to service and

support their e-Research efforts as needed, and guiding the work of the individual proposed e-Research Centre; and

- within e-Research projects involving team members from relevant disciplines and ICT and information management experts – they will build good e-Research teams and drive implementation of successful e-Research practices.

3.2 Coordination of the e-Research Implementation Strategy

The Committee recognises that there will be a continuing need for an informed steering process to coordinate and direct the national e-Research implementation strategy in the next five years, as the Australian research sector undertakes its transition to e-Research.

The Committee therefore proposes in Section 10 of this Report that a successor body, an e-Research Committee, be established, to set the strategic directions and to coordinate the implementation of the e-Research agenda. The Committee further recommends that the proposed national e-Research Leader chairs this e-Research Committee.

RECOMMENDATION

2. The Committee recommends that Ministers appoint an e-Research Leader to champion the e-Research agenda within government and the research community, be the visible face of e-Research, and to chair an e-Research Committee, established to oversee the implementation of the e-Research strategies proposed in this Report.

4 Research, Development & Deployment

4.1 Introduction

The Committee's Interim Report pointed out that Australian researchers have established a respected position in the research underpinning e-Research technologies and in the evolution of standards for e-Research resources. The latter has taken place both through involvement in standards bodies such as IMS/GLC and in international development activities likely to impact on the Australian e-Research scene, including IPv6, Shibboleth and Internet2.

This Section is concerned with the research, development and deployment (RD&D) efforts in the ICT arena that lead to the implementation of the new e-Research capabilities needed by researchers. Australian RD&D, conducted within an international context of RD&D, is pushing the boundaries of ICT capabilities. Commercial and industrial drivers are also important within that context. It is necessary to position Australian RD&D within the broad international (including commercial) context.

4.2 A strategic intervention approach

The Australian research sector in general is characterised by a broad base of excellent domain-based researchers, a highly distributed research environment, including distributed resources, institutions and data repositories, and a need to be internationally involved and competitive.

Considering these national research needs, in the context of international and commercial drivers, and of enablers and constraints relevant to RD&D into e-Research, Australia should pursue research within certain strategic areas, in order to enable and advance our national e-Research capability. These areas include:

- collaborative tools, such as Virtual Organisation management, application sharing, collaborative simulation and experiment steering, collaborative ontology development, support tools and services for Access Grid nodes;
- high performance and distributed computing, for example, resource scheduling, monitoring and management, workflow tools, data-intensive computing with petascale data sets, advanced algorithms and simulation software;
- data management, such as implementing data storage methodologies that are robust with respect to system evolution and upgrading, knowledge extraction and intelligent searching, metadata standards, ontologies, data management, standards and test beds;
- visualisation and presentation tools; and
- security, including federated identity, authentication, authorisation, access management to data, services and instruments, and access management for Virtual Organisations.

The Australian Research Council, through its own processes, has supported RD&D into e-Research and will continue to do so. When funding RD&D that will enable e-Research, the Government should not seek to fund independent projects, as might occur through a purely competitive research support programme. There is general acceptance among the States and stakeholders that the real need in e-Research (and research infrastructure and systems generally) is for strategic intervention rather than a competitively funded programme.

The strategic funding of Australia's RD&D should be provided to both develop Australia's e-Research capability and to develop the capability of Australian researchers to participate in

developments in the international arena. As well as supporting Australian e-Research, this approach will support Australian RD&D products being exported overseas.

In establishing national RD&D priorities to support e-Research, it is important to establish the main processes by which Australia can identify and agree upon strategically important directions, toolsets, platforms and standards to be adopted nationally to support e-Research. A pathway to decisions of this nature needs to be defined, along with a clear idea of which groups should take on the role of identifying the key requirements and solutions on behalf of the many stakeholders. The e-Research Committee proposed in Section 10 of this Report will be well placed to develop and oversee the necessary processes.

4.3 Bridging the gap between research and operational services

The take-up of e-Research will be reliant on the availability of fully functional, scaleable applications, user interfaces and data management and administrative services, defined collectively as ‘operational services’.

Various research projects being conducted under the auspices of bodies including the Australian Research Information Infrastructure initiative, the Building IT Strengths initiative, CSIRO projects, and endeavours of computer science and IT departments of universities and publicly funded research agencies, provide excellent examples of applied research. To enable e-Research, strategically important projects need to culminate in robust solutions, with strong interoperability, reusability or wide accessibility for researchers. A process is needed to bridge the gap between strategically important research projects and operational services, including avenues to deployment, commercialisation as appropriate, support and maintenance. It is not always clear how this should be achieved.

Operational services in Australia cannot be based on experimental platforms. Rather, the development of these functional implementations must be grown by building on knowledge gained through previously successful Australian deployments, where they exist, and by adapting international knowledge to meet Australian needs. To be abreast of deploying services based on Australian R&D or international knowledge, Australia should sustain and enhance its involvement in international activities.

The Committee considers that, in order to bridge this gap, it will be necessary to increase the pool of people adept at connecting university researchers with IT experts, and to identify those organisations best suited to undertake deployment. This activity could also open ICT career pathways for deployment specialists.

In conclusion, the Committee proposes that an RD&D programme should be established to support e-Research in Australia. This programme should be implemented in the form of a strategic intervention, administered through the e-Research Committee. The programme will support activities and services that are important to generate greater deployment of research and development to better enable e-Research in Australia.

RECOMMENDATIONS

The Committee recommends that:

3. Ministers establish a strategic Research, Development and Deployment programme to support e-Research in Australia, to be administered by the e-Research Committee and conducted in the international and commercial context; and

4. That this also includes further funding for existing initiatives developed under the Systemic Infrastructure Initiative and the Building IT Strengths initiative, in order to deploy fully functional applications and tools to enable Australian e-Research.

5 Skills Development

5.1 Introduction

A deeper and more rapid take-up of e-Research in Australia will require a considerable short to medium-term increase of the number of researchers with the confidence, knowledge and technical skills to undertake e-Research, and in the number of IT specialists who can support or participate in e-Research projects with domain-based researchers.

In its Interim Report, the e-Research Coordinating Committee identified three particular skills groups that need to be established or strengthened:

- researchers who need to be confident and proficient in e-Research;
- professionals who can translate between research domains and the necessary ICT specialist knowledge, to assist researchers to use advanced ICT and information management methodologies; and
- experts in ICT and information management who can apply their high level knowledge and ability to particular research projects and to the research, development and deployment of e-Research enabling tools, services and methodologies.

The purpose of the skills development activities within the e-Research Strategic Framework, therefore, will be to provide a feedstock of capable e-Research practitioners for universities and industry, to train experts to assist researchers to use advanced ICT systems and tools in their research and to create a pool of professionals who can design, operate and maintain advanced ICT systems and platforms on which e-Research will depend.

Addressing these skills needs calls for:

- a broad outreach and awareness-raising strategy (discussed in Section 6);
- targeted transitional investments to build up the educational ‘pipeline’ that will populate these cohorts in the longer term; and
- professional development and incentive programmes to encourage and enable existing practising professionals in the public and private sectors to make the transition to e-Research.

5.2 Targeted investments in education and skills development

Education Programme

A key component in the development of Australia’s e-Research capabilities will be the development of a cohort of e-Research practitioners skilled at the higher degree level, who can initiate and carry out new e-Research projects, and apply e-Research methods to existing research programmes in their disciplines. As well as providing a pool of e-Research expertise for the longer term, this newly skilled cohort will be pioneers in their respective disciplines who can stimulate other researchers with whom they collaborate to adopt and adapt these emerging methodologies.

Support mechanisms to encourage modest numbers of students at all stages along this pipeline would, therefore, constitute a catalytic investment to seed and accelerate the growth of e-Research capabilities more widely in Australia’s research communities.

Incentives at the undergraduate and Honours level

Many discipline-based undergraduate programmes offered by Australian universities and vocational training institutions already include a certain amount of ICT training and modules pertinent to the discipline at hand. Australia's e-Researchers of the future will be primed by their exposure, at undergraduate levels, to key skills and practical experience in broad enabling ICT areas, for example, data management, metadata and ontologies relevant to the discipline at hand, IT security, distributed computational methods, advanced search tools, discipline-specific applications, and peer-to-peer collaboration tools.

The Committee endorses and encourages initiatives by educational institutions to remove domain barriers and introduce students to pertinent e-Research methodologies as soon as practicable in their undergraduate courses.

Vacation scholarships offered by universities and research institutions are a potentially useful 'pipeline strategy' to introduce bright undergraduate students to e-Research topics and to encourage them to pursue education pathways related to e-Research beyond their undergraduate courses.

A significant step in populating postgraduate training programmes that will create an advanced Australian e-Research capability would be to establish a five-year programme of *e-Research Honours Scholarships*. Institutions participating in this programme would select and encourage students with appropriate aptitudes in their undergraduate cohorts to undertake appropriate inter-domain honours projects. Students would be jointly supervised by ICT experts and domain-based researchers. The programme would fund specially targeted e-Research Honours scholarships, which would be administered through the proposed e-Research Centre. The Committee considers that around 50 e-Research Honours Scholarships should be available each year as an inducement to students.

Currently, the flow of undergraduate students through the education pipeline is thin in some ICT areas, especially given the lack of 'industry pull' in Australia compared with other countries. This may be exacerbated for the relatively new field of e-Research due to lack of community awareness of what it is all about. It may prove challenging, therefore, to attract sufficient numbers of students to take up this kind of scholarship, but experience at many institutions has shown that even modest financial incentives at Honours level have proved very effective at attracting capable students to intrinsically interesting projects.

The experience gained by creating inter-domain e-Research honours projects will inform the development of future undergraduate coursework programmes in both IT and domain-based degrees. Universities may also consider it advantageous to re-structure undergraduate courses to encourage more students to undertake cross-disciplinary electives.

Postgraduate research

To encourage a cohort of bright graduates to enter or remain in the field of e-Research, the Government should establish a programme of high-profile *e-Research Postgraduate Scholarships*. This programme would provide for up to 35 new three-year Ph.D. scholarships each year, distributed around Australia, and would run for a period of 5 years.

Suitable candidates would originate from diverse domains, e.g., information management, IT systems and a variety of research disciplines. It is expected that the proposed e-Research Honours scholarships will assist greatly in preparing and selecting candidates to populate many of these postgraduate positions.

An important early need in the rollout of an Australian e-Research capability is the development of operational services, applications and tools for researchers in a wide range of disciplines.

Research training at the postgraduate level should, therefore, be orientated towards addressing real needs of end-users, wherever possible.

To advance this cause, the value, conditions and administrative processes for these e-Research Postgraduate Scholarships should be modelled on applications-focused, industry-linked scholarships currently available, such as the Australian Postgraduate Awards (Industry). The e-Research Centre proposed in Section 6 would liaise through its administrative node with the students' host universities, acting in the role of 'corporate collaborator' to provide an implementation focus for the research projects. In particular, students would be strongly encouraged to interact with end-users and discipline-based researchers in this programme.

The award of these prestigious postgraduate scholarships should be contingent upon excellence of the students, the proposed projects and the degree of engagement with the broader community of end-users. This will create incentives for both students and potential supervisors, and will advance national e-Research capabilities in line with the e-Research strategy.

The proposed e-Research Centre would have an important coordinating role, to ensure that the e-Research Postgraduate Scholarships programme as a whole advances the national strategy to enable e-Research. To this end, the proposed e-Research Centre would:

- provide a panel of experts to assist in the selection process for candidates, projects and locations, in order to coordinate and balance research projects across strategically selected e-Research themes;
- encourage the adoption of agreed standards to guide the selection, resource provision, performance management and professional mentoring of scholarship holders across Australia;
- promote collaboration between participating organisations supervising scholarship holders;
- provide a strong end-user focus for the scholarship holders – in particular, to provide a venue or a link to development and deployment activities that stem from the students' research projects, so they are useable by researchers; and
- assist host universities as required in selecting appropriate supervisors and examiners, and in disseminating students' outputs to the e-Research community.

Professional Development

On-the-job experience of researchers, IT professionals and information managers will always be the most effective method for acquiring important e-Research knowledge and skills.

It has become the practice of many universities to prepare postgraduate students for their careers through additional 'professional skills' development, integrated with their research training. Postgraduate training already encompasses important generic and transferable career capabilities in areas such as professional communications, project management or business skills. With the growing importance of e-Research methodologies and ICT-enabled collaboration to discipline-based research, it is becoming imperative that domain-based research students are trained in relevant ICT and information management skills, for example, through short courses, and that IT research students have the opportunity to interact with domain-based researchers, for example through selective research placements or immersion programmes during their postgraduate courses.

For professionals already working in domain-based research areas, or in the support areas, such as IT departments, and libraries, professional development courses and conversion programmes will also be an important avenue for skills acquisition, or for introducing new capabilities.

Specialists such as information managers and ICT professionals would benefit through their existing expertise, by the creation of targeted e-Research short courses and seminars in topics such as metadata, data standards, data management, desktop collaboration tools, distributed computing and resource management. It is expected that the proposed e-Research Centre would have a key role in conducting, coordinating or brokering these specialised courses together with the support of collaborating institutions which specialise in these areas.

Incentives

Institutions will benefit by providing incentives to their own academic teaching staff, ICT staff and information management professionals, as well as their host cost-centres, to encourage the development of courses and research projects involving e-Research.

Institutions themselves should also give detailed consideration to establishing effective incentives to academics to gain e-Research expertise, such as e-Research sabbaticals, teaching relief for 12 months while they gain new skills, seed funds for e-Research projects, and the provision of graduate diplomas or short 'conversion' courses for academics.

Institutional promotion and career advancement processes should render sufficient professional recognition to academics that choose to invest time and expertise in developing and supervising new cross-disciplinary e-Research projects and courseware. Similarly, formal institutional recognition and reward structures should encourage ICT staff and information management professionals to develop and implement systems and facilities for use by researchers.

Institutions should be encouraged to review carefully their internal accounting processes by which they allocate operating budgets to departments that jointly supervise projects and students, so that it is fair and consistent to all involved, and does not create an administrative disincentive to the establishment of joint projects.

Skills considerations for the Industry sector

Initiatives to develop e-Research skills among practising professionals have benefits that extend beyond the pipelines that feed into academic and publicly funded research agencies, and can have a direct impact on industrial R&D and technical operations. It should be recognised, however, that meeting industry skills needs is not merely a matter of providing sufficient professional development opportunities or qualified specialist graduates, but can be impacted by international standards, industry conventions, the practices of certification authorities, commercial supply and demand and demographic circumstances, requiring changes in policy and practice on several fronts.

An example that illustrates the complex issues surrounding industry skills supply is the current skills shortage in the field of IT security. This will have particular importance for companies planning to conduct their own e-Research, or who wish to undertake e-Research collaborations with universities and publicly funded research agencies. Such companies will require skilled professionals who not only have the IT security skills required elsewhere, but also the additional skills needed for work on advanced networks, grid systems, large data stores, multi-organisational collaboration and other areas of IT that are specific to universities and, particularly, e-Research.

Many IT professionals now obtain their specialist industry-relevant accreditations in the form of certificates, training for which is often provided through the private sector. Existing certification schemes for IT security professionals are varied, but most have been developed in the USA and are grounded in US law. Some certification schemes require registrants to undertake particular and expensive commercial preparatory courses, while in others, the training programs are protected IP, reducing both credibility and flexibility. Because commercially provided security

training is extremely expensive, and not always well adapted to Australian industry needs, different approaches may need to be implemented here.

An example of a different, very cost-effective approach is the security training for university IT staff, which is sponsored and largely funded by the Council of Australian University Directors of Information Technology (CAUDIT), delivered by the Australian Computer Emergency Response Team (AusCERT) and hosted by universities in different cities.

Further advantage could be gained through the establishment and adoption in Australia of an international certification scheme that is modular enough to incorporate Australian needs, specifically, and needs of the university and e-Research sector more generally.

It will be important, at least in the initial stages, to consider that it may be necessary to source IT security professionals from overseas countries and this need should be reflected in the policies of the immigration authorities.

RECOMMENDATIONS

5. The Committee endorses undergraduate cross-disciplinary ICT electives and subjects at the undergraduate level that will prepare graduates for career pathways to e-Research.

The Committee recommends that:

6. Ministers agree to the establishment of a five-year programme of one-year e-Research Honours Scholarships, to be administered through the proposed e-Research Centre, to support honours students to undertake projects in e-Research enabling methodologies and cross-disciplinary applications of e-Research;
7. Ministers agree to the establishment of a five-year programme of three-year e-Research Postgraduate Scholarships to support students undertaking research training in e-Research capabilities at the Ph.D. level. This programme should be coordinated through the proposed e-Research Centre; and
8. Ministers encourage the introduction by institutions of formal incentives, recognition and reward mechanisms for the skilled e-Research professionals who support and provide expertise to researchers, and to encourage academics to invest time and expertise to develop cross-disciplinary projects and courses to train a new generation of e-Researchers.

6 Skills Transfer

6.1 Introduction

In addition to the skills development issues considered in Section 5 of this Report, other aspects will need to be addressed. Ways need to be found to increase the interaction of people who have inter-disciplinary skills across ICT, information management and research domains, for the broader benefit of the research community.

A fundamental theme of the Committee's Interim Report was the need for more interaction between discipline-based researchers and professionals in ICT and information management. Without improved interaction, discipline-based researchers will be hindered in their uptake of e-Research, because they will not have the awareness, skills and support they need to use advanced ICT methodologies effectively.

The Interim Report suggested that existing national expertise in e-Research be focused, through the establishment of e-Research Centres, to assist universities and PFRAs in establishing e-Research capabilities, to grow the national skills base in e-Research and to support new innovative activities.

Currently a number of research organisations, including universities and research centres, provide scarce but highly qualified expertise in e-Research tools at the middleware and application levels. Particularly important in this process are the researchers who have expertise in computing, communications and management systems, and who also understand the disciplinary context. However there remains much to be done to extend both the geographic and discipline extent of these activities.

The UK e-Science initiative included programmes to bring researchers together. For example, the programmes coordinated meetings and forums to consider multi-disciplinary research projects. They also raised awareness and addressed various levels of need through e-Research training and support services. In those ways, the expertise of researchers was extended.

The UK approach transferred e-Research expertise to, and through, people. A similar approach would be appropriate for Australia. In that context, the development of the e-Research Centre should be a key focus of the e-Research programme.

6.2 Role of the e-Research Centre

The primary role of the e-Research Centre will be that of a change agent for a strategically important transformation in the overall nature of research in Australia, to embed e-Research methodologies in research practices. The Centre should be established for a finite period of five years, beyond which time the desired changes should be reasonably embedded in the research culture in universities and publicly funded research agencies, reducing or removing the necessity for the Centre to exist outside established institutional frameworks. The Centre will have a role to link with evolving e-Research activities in research institutions to encourage and enhance their development as sustainable platforms for Australian e-Research activities.

It is possible, however, that some functions and roles of the e-Research Centre, e.g. research support, might need to be provided through other mechanisms beyond this time. Hence, before the end of the five year period, the e-Research Committee proposed in Section 10 should conduct a review to determine, in light of experience gained through operating the e-Research Centre, the

most appropriate mechanisms and organisations to meet any identified continuing needs for research support across the sector.

Functions of the e-Research Centre

To achieve the transformation in e-Research, the e-Research Centre will work with researchers, universities and PFRAs to undertake the following functions:

Coordination of e-Research

- increasing collaboration between researchers working in related fields and between organisations;
- achieving coordination of e-Research activities within the overall national e-Research strategy; and
- facilitating connection with international research networks and international research collaboration.

Outreach and awareness raising

- encouraging researchers, universities and PFRAs to adopt e-Research methodologies and capabilities more rapidly;
- generating interest and enthusiasm about e-Research activities;
- delivering outreach services to researchers to raise general awareness of the potential of e-Research methodologies and to put researchers in touch with expertise that can assist in meeting their needs; and
- actively engaging researchers in discussions to help them experiment with e-Research methodologies.

Support services to researchers

- delivering support services to discipline-based researchers conducting e-Research projects.

Skills development

- enhancing the capabilities for e-Research in Australian researchers;
- developing a much larger cohort of people with expertise pertinent to the rapid development of e-Research;
- supporting the development of relevant skills and knowledge through appropriate projects, scholarships and fellowship programmes, as outlined in Section 5 of this Report; and
- coordinating and facilitating professional development and providing a portal to professional development resources.

Coordination of RD&D to support e-Research

- encouraging a more strategic approach to research and development that supports e-Research; and
- assisting with strategic deployment of the outcomes of that research and development.

Centre Leadership

Each node of the proposed e-Research Centre should have a leader capable of generating enthusiasm, attracting high quality support staff and researchers, building excellent teams and coordinating with others involved in the e-Research strategy.

These leaders for the e-Research Framework could be attracted to the role through the establishment of merit-based, high-profile, *e-Research Pathfinder Fellowships*, each of five years' duration. The aim of this programme would be to attract eminent discipline-based researchers from Australian institutions, or eminent expatriate Australian researchers, to make the transition to e-Research, and eminent ICT-based researchers to cross domain boundaries, in order to promote e-Research leadership in their respective domains.

The Committee suggests that this programme, when fully implemented, should support around seven e-Research Pathfinder Fellowships, accountable, through the proposed e-Research Committee, to the e-Research Leader.

e-Research Postdoctoral Fellows

To capture and retain critical expertise emerging from the investment in the e-Research postgraduate programmes, it is essential to provide incentives in the form of postdoctoral career pathways and fellowships in e-Research for the best and brightest PhD graduates.

The Committee recommends that the Government establishes a formal five-year programme of high-profile *e-Research Post-Doctoral Fellowships* (e-PDFs), to be coordinated through the proposed e-Research Committee, in order to coordinate the balance of research areas covered by the positions. Administration of this programme and its associated funds would take place through the administrative office of the proposed e-Research Centre, in conjunction with the Office for Research in each university hosting one of the postdoctoral fellows.

The Committee recommends that this programme should fund up to seven new postdoctoral positions each year (each of three years' duration). These fellowships, along with the postgraduate scholarships previously described, would create an important catalyst for change and academic awareness of e-Research inside the host universities, and a supply of highly adept experts in e-Research methodologies to move out into the research communities. As with the postgraduate scholarships, each e-Research Postdoctoral Fellowship should have a strong end-user focus, with an emphasis on development and deployment of e-Research solutions to meet the needs of the community of researchers across different domains.

This programme would become an important facet of the broader outreach functions to be implemented in the e-Research Framework.

Outreach and Awareness Raising

The primary step to increase Australia's capability in e-Research is to raise awareness among the key participants. This would be a primary role of the e-Research Centre.

New and established domain-based researchers should become fully aware of the possibilities offered by ICT in their disciplines, and as an enabler of new forms of collaboration with other researchers and other sectors. Researchers must gain the confidence, fundamental knowledge and technical skills to incorporate a variety of e-Research methodologies, facilities and tools into their existing research activities, and actively embrace the new technologies to pursue new research directions and collaborations. Similarly, ICT professionals and information managers must be aware of new career pathways by which they can interact with domain-based researchers to enable e-Research projects and to participate as team members in domain-based e-Research collaborations.

These functions should be addressed through a targeted outreach strategy to assist researchers and their IT collaborators to make the transition to e-Research. This strategy will include explicitly supported outreach activities as well as ‘incidental’ outreach opportunities arising from other research and educational programmes and initiatives.

The e-Research Centre could support a number of activities as deemed appropriate by each node, such as attendance and presentations at relevant conferences, delivery of specialised workshops and tutorial sessions at conferences and at the nodes themselves, ‘road-show’ presentations to groups of academics and researchers, and the hosting of ‘user groups’ to allow domain-based researchers to interact with one another, and with experts in IT and information management, on problems and applications of mutual interest.

The e-Research Centre should also assist universities and research institutions to promote, participate in and coordinate their own awareness raising and training activities aimed at practising professionals. The roles of the e-Research Centre in this area would be networking, outreach, publicity, contributed presentations and participation in organising committees, as appropriate in each case. Institutional activities in this theme could include:

- professional exchanges such as visiting fellowships and overseas sabbaticals – these would stimulate visiting researchers from overseas research groups to bring valuable e-Research skills into Australian research communities, and would allow Australian researchers to visit and gain new insights into e-Research applications and methodologies overseas.
- summer schools, internships and immersion programmes for practising researchers – these initiatives could be targeted at both domain-based researchers and ICT researchers investigating the benefits of involvement in e-Research collaborations.
- international conferences, workshops and seminar series on multidisciplinary areas such as bioinformatics, nanoinformatics and geoinformatics – such events would stimulate Australian researchers’ awareness and involvement in state-of-the-art e-Research, and would promote networking and international collaboration.

Coordination of Research, Development & Deployment

Some of the e-Research Centre nodes will develop particular expertise in addition to their general expertise. The areas of special technical expertise in each node should be developed systematically to achieve the spread that is essential, while ensuring that it is broadly accessible to the Australian research community.

In that way, the nodes will form an integral part of the overall e-research strategic framework, by improving interaction between discipline- based researchers and ICT and information management professionals and delivering professional support for researchers to conduct e-Research.

6.3 Structure of the e-Research Centre

The e-Research Centre should be established as a single national centre with up to seven nodes distributed in areas of research concentration in Australia. This structure would:

- enable integrated services and projects to be delivered through a number of nodes that are close to research institutions;
- allow the Centre to interact with and service easily, frequently and at a personal level, the Australian researcher community; and
- reduce the risk of a dilution of effort in the distributed nodes.

The structure of each node, and its overall level of activities, will be determined by local priorities and various levels of co-investment, cooperation and engagement by local and state authorities, institutions and research communities. As a base model, each node might function as a nucleus, employing in the vicinity of five people, for example, an office manager, a research leader and three IT or information management professionals, and would carry out the roles described above. Indications are that this organisational structure will stimulate additional interest and investment on the part of State and Territory governments and institutions to support the e-Research nodes over and above the contribution of the Australian Government, through co-investment or the provision of facilities, personnel or infrastructure. This will significantly increase the functionality, relevance and support role of the local nodes.

A single administrative regime governing the distributed nodes of the e-Research Centre would be appropriate. This singular organisation will ensure that the operations of the nodes remain coordinated and will reduce administrative costs. The proposed e-Research Committee should guide the strategic direction of the Centre. One of the nodes should also have the overall co-ordination and administration role of the distributed nodes as an additional function, together with activities such as budgeting, administration of service delivery aspects, performance monitoring and reporting.

The e-Research Centre should operate in close co-operation with universities and publicly funded research agencies, so that the nodes have a good knowledge of both the research and e-Research activities being conducted in those organisations and to assist in the evolution of e-Research capabilities and structures in those institutions. At the same time, the nodes should not fall within the administrative arrangements of the universities and publicly funded research agencies, to ensure that the operations of the Centre are undertaken most effectively for the research communities it serves.

The co-ordination provided by this e-Research Centre will also be necessary to facilitate the development of the nationally consistent standards, services, systems and operations which are an essential component of an effective e-Research outcome.

RECOMMENDATIONS

The Committee recommends that:

9. Ministers establish an e-Research Centre, consisting of a distributed set of nodes in regions of research concentration, and reporting to the e-Research Committee, for a period of five years, in order to facilitate the transformation of Australian research through the transfer of e-Research methodologies to the research community;
10. Ministers introduce a programme of merit-based, high-profile, e-Research Pathfinder Fellowships, each of five years' duration, to be administered through the e-Research Committee;
11. Ministers agree to the establishment of a five-year programme of high-profile e-Research Postdoctoral Fellowships to support research, development and deployment of e-Research capabilities and methods to be administered through the e-Research Committee; and
12. Ministers support a targeted outreach programme that will raise awareness in the Australian research community of the benefits of ICT and will encourage the transition to e-Research, to be administered through the e-Research Committee.

7 Implementing better access for Researchers

7.1 Introduction

A key enabler for e-Research in Australia is to give researchers seamless access to resources, including each other. The resources are distributed in various areas of Australia and overseas, and include:

- digital data repositories;
- scientific facilities, instruments and sensors;
- computational facilities; and
- high-speed telecommunications networks.

Significant investments have been made, and are continuing to be made, in supplying the above resources. In addition, research has been undertaken into the technical means through which to give researchers access to distant resources. On the demand side, the size and disciplinary mix of researchers seeking operational level services has reached the point where robust authentication systems are required to manage user communities. The services include seamless access to data held in universities, publicly funded research agencies, government agencies and industry; access to data generated by scientific facilities and access to computational capability.

This Section proposes the next steps that must be taken to put in place a national, robust identity provision solution that will allow researchers' identity to be authenticated, and their access authorised, to distributed resources (both within the research sector and more broadly within the national and international government and business sectors) via a single sign-on system. This is an urgent, large and essential first step to give researchers seamless access to distant resources. It will require the coordination of organisational capabilities and technical expertise on a national basis, in a way that is fully compatible with overseas initiatives.

An operational trust federation must be established and maintained so that institutions can routinely interoperate without having to enter into a plethora of bilateral trust relationships. Doing this will enable researchers to collaborate across institutional boundaries without having any need to be involved in the maintenance of the trust relationships that they are using.

7.2 Access, Authentication and Authorisation (AAA)

Currently research organisations, whether they are universities, publicly funded research agencies or private sector bodies, use different software and security systems to enable electronic access by individuals to relevant resources within their own organisation. The emphasis in recent years on improving organisational security, and security of information sent over the Internet, highlights the need to address security issues for effective access to occur.

Access across many different organisations raises issues of:

- the sheer scale of multi-organisational access;
- different levels of access to respect security classifications within organisations;
- audit capabilities, especially for security breaches;
- search capabilities; and
- protection of intellectual property and digital rights.

To enable access, authentication is first required to establish the identity of the user. Once a user has been identified, authorisation is required to determine what types of resources, or privileges, should be given to the user. The latter is often based on the role of the user in their own organisation, for example, researcher. Further requirements are the maintenance of integrity, to ensure that data has not been altered; non-repudiation, to ensure that signed or authorised messages are permanent; and protection of confidentiality, to ensure that data cannot be intercepted without authorisation.

It is essential that e-Research services can support these properties when needed. The e-Research programme should harness achievements to date and incorporate them into a national action plan to establish the necessary governance and further technical arrangements to enable access across organisations.

National coherence is desirable for a range of AAA services in common across research communities. As well as the need to improve accessibility for researchers generally, a further driver will be the funding of NCRIS infrastructure to address high priority research capabilities in Australia. By the very nature of the NCRIS strategy, the resultant NCRIS infrastructure is likely to be distributed and must therefore be generally accessible to the research community it serves.

A number of overseas countries are addressing the access issue. The UK recently announced that it will adopt a technological solution using an ICT system termed “Shibboleth”. Considerable work is underway in Australia through the Council of Australian University IT Directors (CAUDIT) et al to examine the potential of a combination of “Shibboleth” and “PKI” (an encryption method that serves very high security needs) technologies to address the research system-wide needs. The twin approaches of developing both Shibboleth and PKI are intended to provide Australian researchers with services comparable to those being engineered in the US and Europe. The Committee considers that this work must continue with added urgency to mesh with the roll out of NCRIS infrastructure.

An agreed standard set of characteristics for identities across the higher education and research sector in Australia is essential to facilitate exchange of identity information between institutions and organisations. The development of this capability is a key strategic element of the e-Research Strategic Framework. With some of the newer security technology and techniques now becoming available, it is possible to design complex networks with multiple security zones and to provide adequate security to maintain confidence in the network and to meet legal and legislative obligations. These designs are, however, complex and are unlikely to be tackled by any but the very largest universities. The e-Research programme should support the designs being developed once, to be made available to all universities in Australia. Contracts of agreement will be needed on how institutions will conform to an agreed set of practices for authentication and authorisation of users in the higher education and research sector. That will be so that each institution can trust authenticated users from other institutions, being confident that the latter are complying with the agreed standard procedures. A set of guidelines for authentication and authorisation trust federations need to be developed, building on the work of the Meta Access Management Systems Project and the e-Security Framework Project, that are funded by the Department of Education, Science and Training (DEST).

This work would include the necessary arrangements for the establishment and maintenance of federation structures, as well as development of standards for institutional operating practices and procedures appropriate to participation in trust federations. The goals of this work are to minimise duplication, lead to self-supporting federations, and facilitate participation in existing international federations.

International developments in accounting and audit of the use of distributed resources employed in Grids and other e-research activity should be kept under review. This would enable suitable systems to be deployed in Australia as they become available and feasible, and Australian participation as appropriate in such developments.

7.3 Accessibility for the wider community

It is important to researchers, students and the public that research results be accessible as early as possible in the full cycle of research, according to their needs and taking into account confidentiality requirements.

In *Backing Australia's Ability – Building our Future through Science and Innovation*, the Government announced its intention to establish the Research Quality and Accessibility Frameworks for publicly funded research. The Research Quality Framework (RQF) is a major policy reform initiative for the Australian Government. It is aimed at assessing the quality and impact of publicly funded research and, in the first instance, distributing a significant proportion of research block funding to universities on the basis of RQF results. The Research Accessibility Framework will be developed to ensure that information about research and how to access it is available to researchers and the wider community.

As a general statement of principle, the wider community should be able to find out what research is being undertaken and gain access to that research. The Australian Government has spent close to \$40 million on projects that are paving the way for improved access to research data, for example a limited number of digital data repositories have been established and digital rights and access management issues are being progressed.

Implementation of the Committee's recommendations will address e-Research capability issues, which in turn will promote the development of the Accessibility Framework. In particular, technical implementation of access, authentication and authorisation, and development of common standards to aid search and discoverability of data as outlined in Section 9 of this Report, will contribute to the development of the Accessibility Framework.

It is important that the Government support initiatives that will bring research results to the wider community. In that regard, the Government will need to provide broad guidance on what should be accessible to the wider community.

RECOMMENDATIONS:

The Committee recommends that:

13. Ministers note that the interrelated issues of security, access, authentication and authorisation are important in the context of the e-Research Strategic Framework; and
14. Ministers agree to fund, within that Framework, the development by the e-Research Committee of a set of national guidelines for authentication and authorisation trust federations, building on the work of the *Meta Access Management System* Project and the *e-Security Framework for Researchers* Project funded by the Department of Education, Science and Training.

8 Support for the e-Research Fabric

8.1 Introduction

The 'e-Research fabric' refers to the physical resources, software and services that link, or are linked, to enable e-Research activities. They include broadband networks, middleware services, computing capability, scientific instruments, and digital data storage and repositories. Linking the physical resources can significantly add capability as well as capacity to the e-Research infrastructure.

Australia has achieved considerable success in developing appropriate technical infrastructure to enable e-Research. At a conceptual planning level, there are four principal areas of need:

- disciplinary research communities;
- institutional and inter-institutional research management requirements and activities;
- emerging virtual communities; and
- other researchers and the broader community, including industry.

Each area requires particular levels of infrastructure support. Attention to business policies is, therefore, of equal importance to the actual deployment of technologies.

8.2 Systemic Infrastructure

Network structures

e-Research is dependent on networks with high bandwidth, low latency and low jitter. They must also be reliable, support mobility, be connected to local communities and interoperate with international peer networks.

Australia's telecommunications networks, including the AREN, GrangeNet and public telecommunications networks, generally provide high capacity and speed for e-Research, having been enhanced over the past few years. However, there will be an ongoing need to extend broadband capability to more remote institutions in the network and to other key sources of data and resources, including research agencies and cultural institutions.

End-to-end network properties are critical. This requires all sections of a national network strategy to cooperate in achieving performance, especially major sub-networks in the national system such as those operating within institutions. AREN has ensured that research class networks reach all universities and some other publicly funded research agencies, but further action is needed to ensure that firewalls and perimeter services do not restrict seamless 'desk to desk' research.

The reach of the national research network should be kept under continual review to ensure that there are no significant gaps preventing full end-to-end networking.

Virtual Private Networks will become increasingly important as collaborative research methods increase. The technical challenge is to enable research teams to construct 'virtual research environments' on demand and adapted to particular projects. This goal requires that components of the e-Research infrastructure and researchers can interoperate with one another.

Security of e-Research infrastructure has to be addressed at all levels; it cannot effectively be addressed unless it is with respect to all elements in a communication chain.

Research institutions have particular security problems born of their distinctively large bandwidth and their connectivity to global high performance networks. Security of services apart, liability issues are significant.

A distinguishing feature of the networks of many of the larger universities and research institutions is that, as well as operating at very high speed, they have a large number of security zones which need to be separated from each other as well as from the outside world and the large number of roles within them make them highly complex.

The combination of very high speed and complex usage requirements makes it difficult to use many commercial products, such as host-based firewalls and intrusion prevention devices, in universities. Stakeholders in the research community therefore must work in collaboration with existing network facilities and with specialist service providers such as APAC, Grangenet, AARNet and the CSIRO, to develop research networks further, to meet the evolving needs of e-Researchers. Researchers' data and computational access needs will depend on higher levels of integrity, reliability and security being provided by telecommunications networks.

Computing structures

As a result of substantial Government investments in recent years, APAC and a number of universities and PFRAs provide high performance computing facilities in various parts of Australia. Many of these computing facilities are networked and therefore can provide distributed computing capability. In terms of implementing the e-Research agenda, it is important that as many such facilities as possible be available to service researchers' increasing advanced computing needs.

The Committee notes that a review of APAC is imminent to assess future directions. It is important that the future directions support the e-Research strategy.

Development of a National Data Architecture

Data generators, such as scientific facilities, and data holders, such as museums and archives, are rapidly increasing their generation and holdings of digital data. Researchers are increasingly relying on digital data where appropriate, due to its advantages for research analysis. The e-Research consultation process around Australia highlighted the critical need for researchers to have access to data, whether it be scientific data generated by scientific facilities or humanities and social sciences data from historical records and whether it is held in Australia or overseas.

Research outputs are highly dependent on the input data, implying that researchers need to be confident of the accessibility, persistence and integrity of data they need to access. The linking of distributed e-Research resources, such as scientific facilities, digital data repositories and computing capability with researchers, brings with it responsibilities that data accessed in such a way is not only easily accessible, but also that its persistence and integrity are assured so as to meet researchers' needs.

Australia needs to develop an underlying fabric that facilitates capture, storage and subsequent access to research data by the research community, and by the wider community where appropriate, whilst addressing security issues.

Development of the underlying fabric will need to address the following categories of issues:

- policies;
- technical issues;
- security issues;

- data discovery issues;
- service delivery; and
- data quality assurance.

Reviewing Systemic Infrastructure requirements

Given the critical role of high performance computing, network facilities, data repositories and storage facilities to the Australian research sector, the systemic elements of research infrastructure are part of the National Collaborative Research Infrastructure Strategy (NCRIS) *Platforms for Collaboration* capability. Through this mechanism, NCRIS will be able to monitor, support, and respond to the systemic infrastructure needs of researchers.

8.3 Middleware development

Advanced ICT infrastructure comprises more than computer hardware, associated software and telecommunications networks that are used in standard office environments. In particular, it includes a new level of software tools and services, collectively termed ‘middleware’, that link the ICT resources that users need. Middleware provides the common set of services and tools that allows researchers and applications to treat the data repositories, computing, and other disparate resources as if they were one large virtual facility.

Different users, disciplines and applications have traditionally made their own arrangements and written suitable software and systems to achieve some of this access to distributed resources. As the numbers and type of distributed electronic resources has increased, and as collaborative ways of working have increased, it has become evident worldwide that this individual approach can be very wasteful, as it leads to an expensive duplication of resources and an increased risk of developing systems that cannot communicate easily with each other.

Especially within the research community, and now increasingly among the general academic community, a substantial amount of effort is being expended in various international working groups to identify common standards and practices that can eliminate much of this duplication, and to develop systems that can be applied across a wide spectrum of applications and resources. The aim has been effectively to define a “layer” of software and systems that insulates the users and their applications from the particular characteristics of the resources they wish to access. This means that a variety of different applications and users can access the same or a collection of different resources without making special arrangements on a per resource basis or by altering particular applications.

A number of large ‘production-oriented’ projects around the world are developing and deploying middleware. These are cooperating under the auspices of the Global Grid Forum to harmonise their developments and enable grid interoperability. The goal is to create an operational grid infrastructure capable of supporting cooperation by multi-national research teams. A significant achievement is the Globus Toolkit, a key component of most production grids.

Many current e-Research projects, in Australia and internationally, are being undertaken by teams working largely independently. However, many of these projects have common middleware needs. They all require seamless access to e-Research resources in order to access the services offered by those resources.

The *Middleware Action Plan and Strategy* (MAPS) Project, currently being funded under the SII programme, is:

- taking stock of existing middleware activity in Australia; and

- developing a plan of activities and projects for an Australian collaborative middleware strategy.

The MAPS project will guide Australian researchers, universities and other research institutions in the adoption of a common middleware strategy, standards and tools. This must be done in the international context, as Australia must also be able to collaborate with key international research communities, especially in the UK, EU, US and SE Asia. The MAPS project will identify Australia's strengths and hence the unique roles that Australia could play in middleware development.

Arrangements should be put in place to reduce duplication of effort and deliver widespread efficiencies through:

- adoption of a common middleware strategy for Australian researchers;
- availability of services, such as middleware repository services, that researchers can access. Examples of useful common service provisioning are search tools, workflow tools, data mining tools;
- access by researchers to ICT and information management specialists to provide expertise when needed; and
- standardisation of middleware development, in the international context.

Implementation of the above arrangements will require a coordinated approach, to ensure that the foreseen efficiency gains are realised. This should be accomplished through a governance arrangement that provides communication channels amongst middleware experts, user institutions and relevant government agencies, operating in an international R&D and standards development context. The national e-Research Centre proposed in Section 6 of this report will provide the necessary linking mechanisms. Continuing investment in middleware facilities will be encompassed within NCRIS.

8.4 Collaboration tools

Effective collaboration between researchers, including shared access to repositories and related research infrastructure, is intrinsic to the e-Research vision. Collaboration may involve remote control of equipment, sharing of data, access to content in repositories and increasingly communication and conferencing. The latter may include audio conferencing, video conferencing, "whiteboarding" and instant messaging.

All of these technologies are designed to operate across the research network. They depend critically on secure, reliable networks. Uptake at present is constrained by the need to improve these properties.

RECOMMENDATIONS

The Committee recommends that:

15. The e-Research Committee liaise with the NCRIS Committee to recommend to Ministers a strategy for developing a national data architecture, in consultation with the broad community of researchers; and
16. The e-Research Committee oversees the adoption of common middleware and service standards, taking into account Australian and international developments, in the development and provision of operational services, such as middleware repository services, to the Australian research sector.

9 Managing Data

9.1 Introduction

In order to realise the greatest possible benefit from the investments being made in research in Australia, effective management, accessibility and use of research data¹ are fundamental requirements.

Managing data effectively is essential to support the full cycle of research endeavour, from (1) research concept formulation and scoping, (2) the research activity itself, (3) dissemination of the results of research, back to (1) with the generation of new research, starting the cycle over again. The management of data generated by research is also crucial to support collaboration, allow validation of research results, meet legal requirements and facilitate student and public access to research results.

This section identifies the important data management needs of researchers as being:

- data collection and generation;
- data storage and the physical management of stored data;
- the evolution of standards to enable data to be used and interpreted;
- access to data
- long-term archival and preservation of data and policy for retaining and discarding of data.

A case is made for further stakeholder and community consultation to develop an Australian Research Data Strategy, which would guide the management of data needed and used by the research sector.

9.2 Emerging need for the management of research data

Globally, research domains are generating unprecedented quantities of data, and the associated specialist data stores, collections and repositories are proliferating. The Australian Synchrotron when fully operational will generate of the order of 1 Terabyte of data per day. The Pacific and Regional Archive of Digital Sources in Endangered Cultures (PARADISEC) project is an exemplar for organisations facing the challenge of managing cultural data – the organisation, description and preservation of Terabytes of digital objects in federated data stores under unusual rights management constraints. There is an urgent need to manage this anticipated deluge of large volumes of data across many research domains.

A simultaneous trend is the increasing need for researchers to access, relate and validate rapidly growing quantities of information. This in turn is driving the development of new data collections, the associated domain-specific schema describing those data and the standards and policies governing the storage, integrity, use, access, discoverability and life-cycle management of the data.

¹ 'Data', in this Report, refers to any information that can be stored in digital form, including text, numbers, images, audio, video, software, algorithms, equations, animations, model simulations, etc.

'Data management' is taken to mean all of the actions needed to maintain data over its entire lifecycle and over time for current and future generations of users. This distinguishes it from data creation and collection which may or may not take into account management requirements. The term embraces the concept of curatorial care, including archiving and preservation.

9.3 Data management needs of researchers

Data collection and generation

Data that needs to be managed varies greatly in size, scope, usage, planned duration and other dimensions, and can be considered to fall into three functional categories:

- research data, which is specific to a single investigator or research project.
- resource or community data, which is intermediate in duration, standardisation and community of users.
- reference data which is managed for long term use by many users.

The data is generated, collected and used in different ways, and must be managed accordingly.

Best practice strategies will need to be implemented at all organisations that hold data that is useful to researchers' needs. The realms in which this data resides range from universities and research institutions, who may keep their own repositories and research data collections, to 'disinterested' agencies who collect data for their own purposes (e.g. Bureau of Meteorology, Australian Bureau of Statistics).

Data storage and physical management

There is an implicit need to balance, at every stage, the likely accessibility needs of researchers to data against the likely costs to the research sector and the wider community of long term data retention.

Careful ongoing data valuation will be required, in order to implement cost-efficient life-cycle management of the data. This will include, as required, the planned, progressive migration of data to lower cost systems and new media, data qualification and rationalisation to minimise the cost of retaining data, periodic verification of data and media integrity, and standardised regimes for the secure disposal of data no longer required by researchers or the community at large.

As computer systems, applications and standards evolve, data will need to be progressively converted and migrated to new storage media and data formats.

Standards and protocols for data storage and use

Australian researchers require seamless access to and discoverability of research data and interoperability of systems that transmit and make use of that data. Research communities and institutions need better ways to store and manage their data and research outputs in conformance with internationally accepted standards and protocols.

Information on the content, structure, context and source of the data, in the form of 'metadata' needs to be included, stored and managed along with the data, to enable subsequent use, and to aid the future automated search and discoverability of this data by researchers. Communities of researchers are interacting globally to develop standard schemas and ontologies for metadata, allowing data creators and managers to attribute commonly understood and accepted descriptors to their data.

Australian research communities are also engaged in global efforts to develop standardised internet and grid services that support data access and exchange. These include web interfaces, AAA services and network and data transmission protocols.

The Australian Research Information Infrastructure Committee currently advises the Government on funding of strategic information infrastructure projects, including standards

development projects. Australia is currently actively involved, through IMS Australia, in international e-learning standards bodies such as the IMS Global Learning Consortium, which develop standards for data, metadata and interoperability. This may have a bearing on similar issues relating to research data repositories.

Australia's holdings of nationally important research data must be sustainable and useful to future researchers, industry, government and community stakeholders. National standards and protocols governing data storage, data management and associated information and grid services need to be supported by awareness-raising, targeted training and functional policy guidelines, implemented at both the institutional and whole-of-government level. Australian researchers, computer scientists, and specialists in ICT and information management must also remain actively involved in national and international standards development.

Data access

The Committee's Interim Report identified easier access to data by researchers as a critical issue. This access issue may be due to the various standards under which the data is presented, the lack of description under which the data is collected, the lack of proper access permission provided to the data collected, and the data being stored offline. It is suggested that one way to overcome such a lack of access to information collected is to devise a data management plan, prior to the data being collected. Such a data management plan would include information on access to the data, ownership of the data, what data might be preserved or discarded, and conditions under which the data was collected or generated.

Data preservation

Roles and responsibilities for the long-term data management of nationally important data will need to be specified. While careful data management can minimise the costs of data retention, most research funding agencies does not include long term data support when allocating project funds, so there remains a resourcing challenge. The Committee identifies this as a major issue which will require careful consideration, due to its long term financial commitment.

9.4 Towards an Australian Research Data Strategy

Strategic needs, roles and responsibilities

Data management meets researchers' needs by ensuring that the data is preserved, accessible and in a fit state for use. As there are many possible users of the data, national policies to govern data management standards and practices should grow out of the needs of broad groups of research communities, and in cognisance of national and international best practice.

Major contributors

Development of an Australian Research Data Strategy will require cooperation between organisations that enable and invest in data storage, repositories, collections and management, as well as the end-users of data:

- government organisations, institutions and agencies that resource the generation, storage and archiving of research data and the systemic infrastructure that facilitates access to that data;
- groups, organisations and facilities that generate research data, and have the expertise and disciplinary knowledge needed for effective data management;
- research groups and organisations that need to access and use research data, or derived data products; and

- national and state-based data collection and archiving agencies and organisations, which have their own existing data policies and strategies, and a broad cross-section of contributors and end-users.

The Committee contends that these organisations have a collective responsibility to contribute to the development of national strategies guiding the development of Australia's research information infrastructure, and would be best placed to advise on a corresponding Australian Research Data Strategy to regulate the management of data generated by the research sector.

Framework to guide government investments

The Committee identifies the need for an effective strategic framework to guide future government investments in the establishment of data storage facilities and in the long term management of research data.

Some of these investments, in relation to long term preservation of nationally important collections of reference data that serve a diverse set of communities, could be considered in a manner similar to infrastructure investments in major instruments or national research facilities.

Other investments in data storage facilities and management activities for particular domains may be best managed in the form of seed funding or cost-sharing models, in collaboration with communities of end-users with viable business plans and data strategies. Decision criteria and selection processes will need to be developed, to accompany the different Government investment and data resourcing strategies.

International context

The development of an Australian Research Data Strategy must be considered in the international research context, given that Australia's research sector will need to align with prevalent international data management standards in order to engage fully with overseas researchers.

Access by international researchers to Australian research data and vice versa will also be of great national importance, in helping Australia to address major domestic issues, e.g. health of the Great Barrier Reef, study of pandemics, climate change, sustainable agricultural practices, cultural preservation, global financial behaviours and the like.

Organisational responsibilities

The Committee notes that Publicly Funded Research Agencies and data repositories will need to institute their own rigorous data management policies and resourcing processes, to ensure compliance with national requirements and research funding conditions, to meet their legal obligations with respect to owners of data and digital rights, and to serve the long-term archiving and access needs of their data generators and end users. In doing so, these organisations will need to consider carefully their processes and capabilities in regard to making decisions about data, on behalf of their communities of end-users.

Designing an Australian Research Data Strategy

The Committee recommends that the Government convenes a working group to develop an Australian Research Data Strategy that will support a standardised national approach to the management of data collected, generated, and used by the Australian research community. The Working Group should include representatives of the e-Research Committee and will liaise with peak bodies associated with research and data collection and management, including the National Collaborative Research Infrastructure Strategy Committee.

. This working group should operate under terms of reference that include:

- an investigation of the data infrastructure requirements of the Australian research community;
- recommendations on an appropriate strategy for continuing Government investment in research information infrastructure, in collaboration with, and in recognition of existing organisations working in this area;
- identification of the fundamental best-practice data management processes and standards, together with roles and responsibilities for implementing them, that should be implemented across all domains of the Australian research sector, to benefit researchers, government, industry, and the broader community;
- identification of relevant international standards for data management to facilitate engagement and interoperability with international research collaborators, and to enable Australia's e-Researchers to remain globally competitive; and
- identification of potential synergies and links with the data management strategies of national and state-based data collection and archiving agencies and organisations and with the private sector.

The Committee believes that the Australian Research Data Strategy should encompass:

- archiving processes and sustainable data retention frameworks that suit the needs of researchers across different domains and strategies to ensure nationally important data be available and accessible long after their collection;
- a framework to guide Government investments in data storage infrastructure and data management processes;
- strategies and selection processes for Government investments in data storage capacity, national or distributed digital repositories, nationally important data collections and grid-enabled data networks;
- processes for managing data ownership, digital rights and intellectual property in national data management activities;
- engagement with the international community and standards bodies;
- processes by which the Australian research community can engage with other national organisations which have major responsibilities for data management in their domains;
- outreach and education processes to ensure that researchers and organisations are aware of the significance of data management, best international practice, services available and responsibilities that attach to the generation and management of research data; and
- processes by which the community derives benefit from the management of research data, for example, through education and e-Learning, management of digitised data resources of community interest, facilitation of industry access to and use of research data, and community input to the assessment of the value of research data.

The Committee notes that the Prime Minister's Science Engineering and Innovation Council (PMSEIC) is convening a data working group to examine issues surrounding the establishment of an Australian Virtual Repository for scientific information. The Committee believes that the foreshadowed PMSEIC data working group would inform and provide valuable input to the work of the proposed Australian Research Data Strategy working group. However the latter working group would have a much broader brief dealing with research data across all disciplines,

not only science, engineering and technology, and will aim to influence data management across many jurisdictions in the long term.

Digitisation of existing information resources

The Committee has received input from a number of organisations and individuals seeking support for a national strategy and investment programmes to digitise existing non-digital institutional and national data resources, including books, periodicals, documents, artworks, sound recordings, artefacts, official and community records, folios, and research papers.

The Committee notes that the issue of digitisation of data resources falls beyond its Terms of Reference, but recognises that the digitisation of existing non-digital resources provides a number of potential advantages to end users. These include remote and rapid electronic access to information that may reside only in one location, security in preserving and potentially mirroring historically important information, discoverability of previously hidden information through advanced search tools, and compatibility with e-Research methodologies.

The Committee recommends that the Government establishes a process to investigate and assess the needs of the Australian community for digitisation of existing information resources.

RECOMMENDATIONS:

The Committee recommends that:

17. The Government convenes a working group to develop an Australian Research Data Strategy that will support a standardised national approach to the management of data collected, generated, and used by the Australian research community. The Working Group should include representatives of the e-Research Committee and will liaise with peak bodies associated with research and data collection and management, including the National Collaborative Research Infrastructure Strategy Committee; and
18. Ministers establish a process to investigate and assess the needs of the Australian community for digitisation of existing information resources.

10 Coordination, Oversight and Resources

10.1 Introduction

The e-Research Strategic Framework outlined in this report sets out a multi-faceted approach to the adoption of e-Research capabilities in Australia. There is both a diversity of issues to be addressed and research groups to be engaged. The successful development of e-Research capabilities across the research sector requires an inclusive approach and it will be important to have clearly defined oversight and coordination of effort as the implementation of the strategy moves forward.

10.2 Existing advisory and coordinating arrangements

There are existing Committees, established to guide investments in systemic research infrastructure under the \$246 million Systemic Infrastructure Initiative (SII) managed by DEST.

The Australian Research and Education Network Advisory Committee (ARENAC) is charged with the responsibility of assessing the best options and opportunities in the development of the Australian Research and Education Network (AREN). The AREN now represents a world class national research and education network, providing the essential communications backbone to support many e-Research applications operating nationally and internationally.

The Australian Research Information Infrastructure Committee (ARIIC) has been developing a holistic approach to research information infrastructure and scholarly communication issues. ARIIC has successfully obtained SII funding from the Government to commission a number of ground breaking research and development projects, many of which have resulted in proof-of-concept and demonstrator applications of e-Research.

The SII funding will cease as of the end of 2006 and the programme is in the process of being replaced by the \$542 million National Collaborative Research Infrastructure Strategy (NCRIS). The focus of this programme is to fund the infrastructure needs of identified, national priority research capabilities. Future decisions concerning investments in systemic research infrastructure will fall within the purview of the NCRIS Committee.

10.3 Proposed e-Research Coordinating arrangements

The Committee recommends that an e-Research Committee be established to replace the existing Coordinating Committee in order to implement the e-Research Strategic Framework. The new Committee would provide the strategic direction, drive and engagement and coordination of effort of research groups involved in e-Research. It would also take account of existing SII advisory structures and develop a close working relationship with the NCRIS Committee and its facilitators.

It is envisaged that the Committee be established at a high level and answerable to the Minister for Education, Science and Training and the Minister for Communications, Information Technology and the Arts. The proposed membership would comprise:

- the national e-Research Leader, as Chair of the e-Research Committee
- and nominees of:
- the Minister for Education, Science and Training;
 - the Minister for Communications, Information Technology and the Arts;

- the Australian Research Council;
- the National Health and Medical Research Council;
- CSIRO; and
- National ICT Australia

The new Committee would assume the responsibility for the implementation of the e-Research Strategic Framework outlined in this Report, namely:

- oversee the establishment of the Australian e-Research Centre and its various nodes;
- ensure that the outreach and engagement strategies deployed by the Centre are coordinated, strategic and sufficiently inclusive of the broader research community;
- discern and identify directions and objectives for e-Research in Australia, in the context of other Australian Government investments and initiatives, including the National Collaborative Research Infrastructure Strategy, the Research Quality and Accessibility Frameworks and the National Research Priorities;
- set strategic directions, in the domestic and international context, for Australian research, development and deployment of facilities, services and toolkits and to enable e-Research across all domains;
- oversee the development and implementation of the education and research programmes outlined in this Report aimed at building Australia's e-Research skills base;
- provide the governance body through which the national e-Research Leader and proposed e-Research Centre would report to the Ministers; and
- establish, from time to time, specific purpose, time-limited working groups to address specific e-Research issues and developments through a nationally consistent approach, for example the development of the Australian Research Data Strategy.

10.4 Funding arrangements

As indicated in Section 2, the e-Research Strategic Framework proposes a number of strategic interventions to accelerate the development and adoption of Australia's e-Research capabilities. The emphasis is on leadership and coordination and is complemented by investment in skills development, skills transfer and research capability.

Given the Australian Government's \$8.3 billion investment in research and research infrastructure over 2001-02 to 2010-11, an appropriate investment in e-Research capabilities is recommended strongly by the Committee to ensure the maximum return on this large commitment. The components of this return on investment include:

- maximising access by researchers to government funded infrastructure;
- reforming the researchers' workplace to improve efficiency and effectiveness – this includes issues such as ease of access to distributed data collections, remote access to research facilities, improved communications to support large scale collaborative research;
- building research capacity to address major environmental and social research challenges in the national interest;
- raising the profile of Australian research capability internationally;
- providing a leading role for the adoption of advanced ICT by industry and business; and

- improving the skills base of researchers necessary to support the deployment of advanced ICT across various sectors of the economy, including research, industry, business and government.

The Committee has undertaken an initial costing of the elements of the strategy and this indicates that the basic strategic interventions would require funding of approximately \$25 million per year over a five year timeframe.

RECOMMENDATION

19. The Committee recommends that Ministers establish an e-Research Committee, chaired by the national e-Research Leader, to oversee the implementation of the e-Research Strategic Framework. The Committee will promote coordination of effort and set directions and objectives to increase adoption of e-Research methodologies in Australia, in consultation with the research sector and the community of stakeholders.

Appendix A: Recommendations

Strategic Framework for e-Research in Australia

1. The Committee recommends that Ministers note that the implementation of the e-Research Strategic Framework is critical to the success of e-Research in Australia, and agree to implement the strategic plan of action outlined in this report.

Leadership and Coordination

2. The Committee recommends that Ministers appoint an e-Research Leader to champion the e-Research agenda within government and the research community, be the visible face of e-Research, and to chair an e-Research Committee, established to oversee the implementation of the e-Research strategies proposed in this Report.

Research, Development & Deployment

The Committee recommends that:

3. Ministers establish a strategic Research, Development and Deployment programme to support e-Research in Australia, to be administered by the e-Research Committee and conducted in the international and commercial context; and
4. That this also includes further funding for existing initiatives developed under the Systemic Infrastructure Initiative and the Building IT Strengths initiative, in order to deploy fully functional applications and tools to enable Australian e-Research.

Skills Development

5. The Committee endorses undergraduate cross-disciplinary ICT electives and subjects at the undergraduate level that will prepare graduates for career pathways to e-Research.

The Committee recommends that:

6. Ministers agree to the establishment of a five-year programme of one-year e-Research Honours Scholarships, to be administered through the proposed e-Research Centre, to support honours students to undertake projects in e-Research enabling methodologies and cross-disciplinary applications of e-Research;
7. Ministers agree to the establishment of a five-year programme of three-year e-Research Postgraduate Scholarships to support students undertaking research training in e-Research capabilities at the Ph.D. level. This programme should be coordinated through the proposed e-Research Centre; and
8. Ministers encourage the introduction by institutions of formal incentives, recognition and reward mechanisms for the skilled e-Research professionals who support and provide expertise to researchers, and to encourage academics to invest time and expertise to develop cross-disciplinary projects and courses to train a new generation of e-Researchers.

Skills Transfer

The Committee recommends that:

9. Ministers establish an e-Research Centre, consisting of a distributed set of nodes in regions of research concentration, and reporting to the e-Research Committee, for a period of five years, in order to facilitate the transformation of Australian research through the transfer of e-Research methodologies to the research community;

10. Ministers introduce a programme of merit-based, high-profile, e-Research Pathfinder Fellowships, each of five years' duration, to be administered through the e-Research Committee;
11. Ministers agree to the establishment of a five-year programme of high-profile e-Research Postdoctoral Fellowships to support research, development and deployment of e-Research capabilities and methods to be administered through the e-Research Committee; and
12. Ministers support a targeted outreach programme that will raise awareness in the Australian research community of the benefits of ICT and will encourage the transition to e-Research, to be administered through the e-Research Committee.

Implementing better access for Researchers

The Committee recommends that:

13. Ministers note that the interrelated issues of security, access, authentication and authorisation are important in the context of the e-Research Strategic Framework; and
14. Ministers agree to fund, within that Framework, the development by the e-Research Committee of a set of national guidelines for authentication and authorisation trust federations, building on the work of the *Meta Access Management System* Project and the *e-Security Framework for Researchers* Project funded by the Department of Education, Science and Training.

Support for the e-Research Fabric

The Committee recommends that:

15. The e-Research Committee liaise with the NCRIS Committee to recommend to Ministers a strategy for developing a national data architecture, in consultation with the broad community of researchers; and
16. The e-Research Committee oversees the adoption of common middleware and service standards, taking into account Australian and international developments, in the development and provision of operational services, such as middleware repository services, to the Australian research sector.

Managing Data

The Committee recommends that:

17. The Government convenes a working group to develop an Australian Research Data Strategy that will support a standardised national approach to the management of data collected, generated, and used by the Australian research community. The Working Group should include representatives of the e-Research Committee and will liaise with peak bodies associated with research and data collection and management, including the National Collaborative Research Infrastructure Strategy Committee; and
18. Ministers establish a process to investigate and assess the needs of the Australian community for digitisation of existing information resources.

Coordination, Oversight and Resources

19. The Committee recommends that Ministers establish an e-Research Committee, chaired by the national e-Research Leader, to oversee the implementation of the e-Research Strategic Framework. The Committee will promote coordination of effort and set directions and objectives to increase adoption of e-Research methodologies in Australia, in consultation with the research sector and the community of stakeholders.

Appendix B: e-Research Coordinating Committee

Terms of Reference

Introduction

The virtual research environments emerging from the increasing use of distributed high-performance computing resources, data resources, grid networks and communications technologies have enabled researchers to perform their research independent of time and geographical location - interacting with colleagues, accessing remote instrumentation, sharing distributed research data and computational resources, and accessing information in digital libraries.

The term "e-Research" embraces those virtual environments that facilitate real research collaborations of multidisciplinary, inter-disciplinary, or intra-disciplinary and large or small scale nature involving researchers and research organisations, nationally and internationally. While it is relatively new as a structured concept, e-Research has started to underpin all scientific disciplines, including the social sciences, and humanities.

In common with the USA, the UK, the European Commission, and Japan, Australia has invested in system-wide infrastructure to support e-Research to ensure that its researchers remain globally relevant and competitive.

The key elements of Australia's e-Research infrastructure strategy includes:

- robust high-bandwidth advanced communications networks (e.g. the Australian Research and Education Network - AREN, the Centre for Networking Technologies for the Information Economy - CeNTIE, the GRid And Next GEneration Network - GrangeNet);
- distributed high-performance computing and data storage capacities (e.g. the Australian Partnership for Advanced Computing – APAC, and APAC partners);
- accessible data and information repositories (e.g. a range of implementing projects under the Australian Research Information Infrastructure Committee - ARIIC);
- accessible research instruments and facilities (e.g., through Major National Research Facilities program, and the ARC Linkage Infrastructure Equipment and Facilities program); and
- agreed standards and coordinated middleware development (e.g. through the MAMS project supported by ARIIC, public key infrastructure project supported by DCITA, and GrangeNet).

The ARC has introduced under its Special Research Initiative scheme a pilot funding scheme in e-Research, designed to provide incentives to researchers to overcome the initial high barriers of adoption of the e-Research methodology.

State governments, Universities, and research institutions/organisations have also separately invested heavily in e-Research infrastructure (physical and intellectual) to ensure Australia is participating effectively in global e-Research activities and our research sector remains internationally competitive.

There are, however, issues of common interests shared by all, and emerging issues which are beyond the capacity of any individual agency, institution or research organisation to address.

These issues might be addressed in a more cost effective way by coordination and collaboration, nationally and internationally. For example:

- legal issues such as access to data sets containing personal/privacy information, protection/ sharing of intellectual property, indemnity issues etc.;
- cultural issues such as those related to creating trust in the ‘virtual’ environment;
- the need to provide researchers with access to the resources necessary to enable them to review the work of other scholars, access information and data in a variety of formats and to disseminate the results of their own endeavours;
- the need to co-ordinate activities among a number of funding initiatives in various funding agencies so that a national strategy in e-Research may be achieved;
- the need to engage industries and business enterprises in adopting e-Research methodology in their enterprise systems; and
- the need to engage agencies in both federal and state governments in adopting e-Research methodology in their e-government endeavours.

The e-Research Coordinating Committee Initiative

The Federal Government has conceived an initiative to establish an overarching e-Research Coordinating Committee charged with the responsibility for establishing strategy and policy to coordinate support for research utilising advanced research infrastructure, including distributed high performance computing and research data resources and high speed networks.

This initiative focuses on strengthening multidisciplinary teams working in national priority areas by providing incentives, guiding policies, and capacity building to participate in national and international research programmes. The coordinated and targeted approach will be pursued over sufficient sustained periods to ensure that not only national research outcomes are achieved, but also the changes in research collaboration culture are achieved. The work of the Committee is expected to better inform e-Research investment decisions made under the National Collaborative Research Infrastructure Strategy (NCRIS) announced in *Backing Australia’s Ability – Building Our Future through Science and Innovation (BAA-BOFSI)* as well as government funding programs administered by various portfolios and agencies, such as the Department of Education, Science and Training (DEST), the Department of Information and Communications Technology and the Arts (DCITA) and the Australian Research Council (ARC).

The Role of the e-Research Coordinating Committee

The e-Research Coordinating Committee will be the primary source of expert advice to the Government and NCRIS about developing Australia’s e-Research capacity to capitalise on the Government’s substantial investments in national and international broadband networks, high performance computing, instrumentation, large experimental facilities, and research information infrastructure.

The Committee will be responsible for the national coordination of efforts to build Australia’s e-Research and research information management capabilities, in particular:

- to communicate with stakeholders and promote greater collaboration among Australian researchers and between them and industry to make use of the existing infrastructure of networks, high performance computing and other research resources;

- to facilitate the development of international research linkages through the use of distributed networks, high performance computing and other research resources;
- to advocate and foster the cooperative development of high-quality research capacity in emerging areas;
- to encourage the development of a network of e-Research communities of interest to provide e-Research outreach to the broader research community and to ensure the rapid dissemination of the appropriate skills;
- to engage industry and associated research facilities to sustain efforts in developing national e-Research capabilities, in innovative research and development, and knowledge and technology transfer; and
- to advise on the strategy, planning, management and assessment of the e-Research collaborative projects and activities to ensure that Australia's investments in e-Research provide best value for money, focusing on research in National Priority Research areas.

In undertaking this role, the Committee will:

- contribute substantially to the development of the Accessibility Framework outlined in BAA-BOFSI, which is intended to provide a strategic framework to improve access to and quality of research information, outputs and infrastructure;
- make recommendations concerning initiatives for possible funding under NCRIS which will encourage the development of ICT standards and middleware;
- provide advice on:
 - the priorities for e-Research funding to ensure the maximum economic and long term return, specifying outputs, targets and performance measures;
 - strategies for ensuring a co-ordinated approach to e-Research developments across the communities;
 - strategies for co-ordinating e-Research developments with other national and international academic and industrial partners interested in the development of grid and related technologies;
 - opportunities for technology transfer to and from industrial and other academic IT interests;
 - strategies for assisting industry uptake of e-Research methodology and grid technology;
 - strategies for assisting government uptake of e-Research methodology and grid technology in its e-government initiatives;
 - strategies for obtaining e-Research funding for activities undertaken in the community, including overseas sources of funding from partner organisations for complementary activities; and
 - strategies for a sustainable e-Research effort to inculcate a collaborative culture among our researchers.
- pursue formal relationships with international agencies such as the Joint Information Systems Committee (JISC) in the UK, the US National Science Foundation (NSF) etc.

Composition of the Committee

The Committee will serve primarily as an expert reference group rather than a representative group. It consists of:

- a Chair; and
- one nominee each from the following groups:
 - Australian Vice-Chancellors' Committee (AVCC);
 - National Academies Forum;
 - National Health and Medical Research Council;
 - Council of Australian University Librarians;
 - Australian Research Council (ARC);
 - CSIRO;
 - National ICT Australia (NICTA);
 - an Australian industry representative;
 - Department of Education, Science and Training (DEST); and
 - Department of Information and Communications Technology and the Arts (DCITA).

The above-mentioned organisations will be invited by the Minister for Communications, Information Technology and the Arts to participate on the Committee for its initial term of two years. Their term may be extended subject to the outcome of the review of the Committee towards the end of its initial term.

e-Research Reference Group

The Committee will be supported by an e-Research Reference Group which consists of nominees nominated by the above organisations and nominees from the organisations listed below, who are:

- able to bring broad areas of relevant expertise, both nationally and internationally;
- technically competent to be able to report on developments and plans within their respective areas of responsibility; and
- able to communicate and disseminate information with their particular stakeholder group.

These organisations include:

- National Health and Medical Research Council;
- Australian Government Department of Tourism and Resources, Department of Attorney General, Australian Government Information Management Office, National Archives, Defence Science and Technology Organisation;
- universities;
- the Online Council;
- Council of Australian State Libraries;
- consortia funded under the Government's Advanced Network Programme, namely MNet, GrangeNet and CeNTIE;

- committees formed under the Systemic Infrastructure Initiative: ARENAC, ARIIC;
- Australian Partnership for Advanced Computing (APAC);
- AARNet (Australian Academic and Research Network);
- Council of Australian University Directors of Information Technology (CAUDIT);
- CRCs;
- organisations active in the e-Learning community, such as ACODE and ASCILITE; and
- organisations active in the development of standards for ICT in education and research such as IMS Australia.

State and Territory Governments will also be approached to provide a point of contact to coordinate consultations and communication about e-research issues.

The Committee may, if required, form working groups, expert advisory group, and subcommittees dealing with such issues as applications of IT, certification, middleware policy, data curation, security and governance. Any other person may also attend with the agreement of the Chairman of the Committee.

Expected outcomes

The Committee will undertake necessary consultations with relevant stakeholders nationally and internationally and recommend options to the Government in the form of a strategic framework setting out and prioritising the e-Research opportunities likely to arise within the next ten years or so. This strategic framework will include a description of the technologies required to realise these opportunities, an estimate of the cost, and a timeframe for investment decisions to be made on each.

The recommended options should include appropriate communication strategies for each of the identified stakeholders. These strategies will guide the Committee in communicating with stakeholders to promote sustained e-Research collaboration and raise awareness of national e-Research capabilities and facilities. Some issues are suggested in Attachment A.

The Committee's recommendations should seek to encourage collaboration between researchers, research institutes/organisations and engage industry or State and Territory government partners. A strong emphasis will be given to building an e-Research community of interest to support researchers in their aim to improve their research outcomes through more effective utilisation of new technologies and knowledge. The focus of the Committee's advice to Government will be on achievable outcomes, within the limited available resources, and may draw upon work already undertaken by various stakeholders.

The Committee's recommendations will be considered by the Government as a basis for a strategic framework to inform the extent of funding required in subsequent years to address emerging national e-Research needs.

Term and Costs

The Committee will be established initially for two years. Its ongoing role will be reviewed before its term finishes.

The costs of supporting the Committee and to commission necessary studies and demonstrator projects could be drawn from existing programmes in the DCITA and DEST portfolios, subject to the appropriate Ministerial approval..

Reporting

The Committee will provide to both Ministers:

- by 30 September, 2005, an interim report outlining e-Research issues of national importance in short and medium term and associated strategic options to address these options and report substantively on the Accessibility Framework.
- by 31 December, 2005 a recommended implementation strategy to incorporate the Accessibility Framework in the funding agencies' strategies, including financial implications and appropriate communication plans for each of the identified stakeholders.
- by 31 March, 2006 a report summarising advice from the funding agencies about how they will implement the Accessibility Framework; and
- by 31 December 2006 an update on the implementation of recommended strategies.

Committee Membership

The following people represented the organisations participating in e-Research Coordinating Committee:

Organisation	Representative
Chair of the Committee	Dr Mike Sargent AM
Agere Systems Australia	Dr Chris Nicol
Australian Research Council	Professor Ah Chung Tsoi
Australian Vice-Chancellors' Committee	Professor Doug McEachern
Council of Australian University Librarians	Ms Cathrine Harboe-Ree
Commonwealth Scientific and Industrial Research Organisation	Dr Alex Zelinsky
National Academies Forum	Professor Edwina Cornish
National ICT Australia	Professor Brian Anderson
National Health and Medical Research Council	Professor Alan Pettigrew
Council of Australian University Directors of IT	Mr Nick Tate
Department of Education, Science and Training	Dr Evan Arthur
Department of Communications, Information Technology and the Arts	Dr Rod Badger
Department of Industry, Tourism and Resources	Ms Kerri Hartland

Appendix C: Subcommittees

The Computer Science Expert Group (CSEG) and the Technical Working Party (TWP) were appointed by the Chair of the e-Research Coordinating Committee, to advise the Committee on specific aspects of a national e-Research Strategy and implementation programme.

Computer Science Expert Group (CSEG)

The CSEG was convened to provide input on Australia's education and skills needs, strategic research directions that will support e-Research, and possible implementation steps that can be recommended to the Minister of Education, Science and Training, and the Minister of Communications, Information Technology and the Arts.

Membership

The following people were appointed to the Computer Science Expert Group. (Multiple names appearing for a given organisation indicate that substitute or replacements were appointed at some meetings.)

Representatives	Organisation
Dr Mike Sargent	Chair
Professor David Abramson	Monash University
Professor Paul Bailes, Professor Jane Hunter	University of Queensland
Professor Mike Brooks, Dr Paul Coddington	University of Adelaide
Professor Kevin Fynn	W.A. Telecommunications Research Institute
Professor Ian Gorton	National ICT Australia
Professor Gernot Heiser	University of New South Wales
Professor Rao Kotagiri	University of Melbourne
Professor John Richards, Dr Henry Gardner, Dr Alistair Rendell	The Australian National University
Professor Arun Sharma, Professor Simon Kaplan, Professor Kerry Raymond	Queensland University of Technology
Dr Alex Zelinsky, Dr Dennis Cooper	CSIRO ICT Centre

Terms of Reference

- Devise and evaluate strategies and initiatives that would advance the professional capabilities of researchers, across the spectrum of disciplines, to apply e-Research techniques in their own work;
- Consider possible processes by which Australia's Publicly-Funded Research Agencies (PFRA's) and universities could foster productive collaboration, on an equal footing, between ICT researchers and discipline-based researchers, and influence professionals, graduates and students to regard e-Research as a valid ICT career path in its own right;
- Identify measures that could be taken to enhance the available pool of expertise in the IT service sector who can support research groups across all disciplines to use e-Research methodologies;

- Identify strategic directions and relative national strengths for computer science research and development that Australia could productively pursue in an international context in order to advance the national e-Research capacity;
- Advise on feasible options for implementation, including an order of costs, to support the Committee's recommended strategy to the Government; and
- Provide its advice to the e-Research Coordinating Committee Chair to inform the Committee's Final Report.

Technical Working Party

The Technical Working Party was appointed to consider a wide range of technical and policy issues relating to the infrastructure and services needed to support e-Research, to accelerate the uptake of e-Research infrastructure, and to implement the e-Research Strategic Framework.

Membership

The following people were appointed to the Technical Working Party. (Multiple names appearing for a given organisation indicate that substitute or replacements were appointed at some meetings.)

Representatives	Organisation
Professor Robin Stanton	Chair
Mr Paul Davis	GrangeNet
Mr Alan McMeekin, Mr Neil Clarke	Monash University
Mr Nick Tate	ITS, AusCERT, University of Queensland
Mr Peter Nissen	National Broadband Adviser for Education
Mr Chris Hancock, Dr Alex Reid	AARNet Pty Ltd
Professor John O'Callaghan, Dr Rhys Francis	Australian Partnership for Advanced Computing (APAC)
Professor Neil McLean	IMS Australia
Dr Dennis Cooper	CeNTIE Networking Technologies Laboratory , CSIRO ICT Centre

Terms of Reference

- Consider a range of technical issues including applications of IT, data management including data curation, security, access, authentication, authorisation, certification, middleware policy, governance etc;
- Advise on feasible technical options for implementation, preferably with clear cost-benefit analysis, to support the Committee's recommended strategy to the Government; and
- Provide its advice to the e-Research Coordinating Committee Chair to inform the Committee's Final Report.

Appendix D: Submissions Received

The Committee wishes to acknowledge the following organisations and individuals who provided submissions and case studies.:

AARNet Pty Ltd	Government of South Australia - Department of Education and Children's Services,
Alcatel	Government of Victoria - Multimedia Victoria
ARC Molecular and Material Structure Network (MMSN)	GrangeNet
Astronomical Society of Australia	Griffith University
Australian Bureau of Statistics	Howard Florey Institute
Australian Computer Emergency Response Team (AusCERT)	Jon Mason
Australasian Council on Open, Distance and e-Learning (ACODE)	Neil McLean
Australian Government - Department of Industry, Tourism and Resources	Monash University
The Australian National University	Peter Nissen
Australian Partnership for Advanced Computing (APAC)	National ICT Australia (NICTA)
Australian Partnership for Sustainable Repositories (APSR)	National Neuroscience Facility
Australian Research Council (ARC)	Open Source Industry Australia
David Beanland	Pacific and Regional Archive of Digital Sources in Endangered Cultures (PARADISEC)
Kerry Blinco	Queensland University of Technology
Council of Australian Postgraduate Associations	RMIT University
Council of Australian University Directors of Information Technology (CAUDIT)	South Australian Partnership for Advanced Computing (SAPAC)
Centenary Institute of Cancer Medicine & Cell Biology	Telethon Institute for Child Health Research
Centre for Social Research	The University of Canberra
Charles Darwin University	The University of Melbourne
Collections Australia Network	The University of Queensland
Council of Australian University Librarians (CAUL)	The University of Southern Queensland
CSIRO ICT Centre	The University of Sydney
Curtin Business School, Curtin University of Technology	The University of Technology, Sydney
Simon Fenton-Jones	The University of Western Australia
	University of Sydney Institute of Marine Science
	Victor Chang Cardiac Research Institute
	Victorian Partnership for Advanced Computing (VPAC)
	Walter & Eliza Hall Institute of Medical Research

Appendix E: Glossary

AARNet Australian Academic and Research Network

A licensed carrier that provides high-capacity Internet services between eight state and territory based regional Points of Presence for 37 universities plus research institutions.

Access Grid

The ensemble of resources used to support human interaction across the grid such as multimedia displays that support large-scale meetings, collaborative work sessions, seminars, lectures, tutorials and training.

ACODE Australasian Council on Open, Distance and E-Learning

The peak Australasian organisation for universities engaged or interested in open, distance, flexible and e-learning. ACODE seeks to influence policy and practice at institutional, national and international levels through disseminating and sharing knowledge and expertise, supporting professional development and providing networking opportunities, investigating, developing and evaluating new approaches, advising and influencing key bodies in higher education and promoting best practice.

ANP Advanced Network Program

An Australian Government program managed by DCITA, established to identify Australia's future requirements for communications technologies and communication services.

APAC Australian Partnership for Advanced Computing

A national partnership of eight organisations, one in each State (Queensland Parallel Supercomputing Foundation, Australian Centre for Advanced Computing and Communications, Victorian Partnership for Advanced Computing, South Australian Partnership for Advanced Computing, Tasmanian Partnership for Advanced Computing and West Australia Interactive Virtual Environments Centre) as well as the Australian National University (ANU) and CSIRO. It provides advanced computing, information and grid services to the Australian research community. APAC is responsible for Australia's largest supercomputing facility at ANU.

ARC Australian Research Council

A body that provides advice to the Minister for Education, Science and Training on research matters and makes recommendations to the Minister for the funding of research proposals.

AREN Australian Research and Education Network

High-bandwidth telecommunications infrastructure to increase connectivity to Australia's universities and the wider research community, especially in regional areas. This network was funded from the Australian Government's Systemic Infrastructure Initiative to address Australia's needs in education and research.

ARENAC Australian Research and Education Network Advisory Committee

An expert committee established to facilitate collaboration in the development of the Australian Research and Education Network and provide advice to the Minister on the strategic investment necessary to achieve the AREN vision.

ARIIC Australian Research Information Infrastructure Committee

A committee set up by the Department of Education, Science and Training to support and fund research information infrastructure in Australia.

AusCERT Australian Computer Emergency Response Team

An independent, not-for-profit team of IT security professionals, based at The University of Queensland, which provides computer information security advice to the Australian public, its members, including the higher education sector. AusCERT is the single point of contact for dealing with computer security incidents affecting or involving Australian networks.

Backing Australia's Ability – Building our Future through Science and Innovation

A Government funding package totalling \$5.3 billion over seven years from 2004-05, to support research and development, commercial application of ideas and to develop and retain skills. This package, announced by the Prime Minister on 6 May 2004, builds on the initial 2001 *Backing Australia's Ability* investment of \$3 billion over five years to 2005-06.

Bandwidth

In a digital telecommunications system, a measure of the data throughput capacity of a data transmission channel or network, generally specified in bits per second (bps).

Bit

The basic binary unit of information or data. A bit can have a value of 0 or 1.

BiTS Building on IT Strengths Program

A program funded by DCITA to provide services, support and seed capital to information and communications technology (ICT) start-up companies, and start-up companies using ICT as a key business driver.

bps bits per second

Frequency of bits (of data) recorded, read or transmitted per second in a computer or network.

Byte

A standard unit of information used in computers, in data storage and in networks. One Byte comprises eight sequential bits.

CAUDIT Council of Australian University Directors of Information Technology

Established to promote and advance the use and support of information technology in teaching and learning, research and administration in the Universities of Australia and New Zealand. Members are senior IT officers in the Universities with direct responsibility for information technology.

CAUL Council of Australian University Librarians

Established to provide a common voice and representation for all university libraries, provide a forum for discussion, and promote common interests. Membership is limited to those libraries whose parent institution belongs to Australian Vice-Chancellors' Committee.

CSIRO Commonwealth Scientific and Industrial Research Organisation

An independent statutory authority undertaking a wide range of research activities.

Data Management

Managing the storage and use of data from the time it is generated or collected, maintaining its integrity, security and useability, and ensuring that it can be discovered and re-used by others for as long as it is required.

DCITA **Department of Communications, Information Technology and the Arts**

DEST **Department of Education, Science and Training**

Distributed Computing

The process of aggregating the power of several computing entities to run a single computational task in a transparent and coherent way, so that they appear as a single, centralised system.

eduPerson

A set of information (LDAP object class) to identify uniquely a person on an educational network. This information, being defined by the EDUCAUSE/Internet2 eduPerson task force, will include a common list of widely-used person attributes and definitions in higher education. The task force plans to draw on the existing standards work in higher education, select items that are of broad utility, and define a common LDAP representation for each of them.

e-Security Framework for Research Project

A project, funded through the Systemic Infrastructure Initiative and overseen by the Australian Research Information Infrastructure Committee (ARIIC), to establish an E-Security framework which will integrate different two types of security systems, PKI and Shibboleth, to foster collaboration and enable the secure sharing of resources and research infrastructure within Australia and with international partners. The project will leverage off existing work in both areas, build on the advantages of these different systems and create a platform to enable the secure sharing of resources for and research infrastructure.

Global Grid Forum

An international community of users, developers, and vendors leading the global standardisation effort for grid computing. The community consists of thousands of individuals in industry and research, representing over 400 organizations in more than 50 countries. Within this Forum, community-initiated working groups develop best practices and specifications in cooperation with other leading standards organizations, software vendors, and users.

Globus Toolkit

Fundamental enabling technology for the "Grid" that lets people share computing power, databases and other tools securely, online, across corporate, institutional, and geographic boundaries without sacrificing local autonomy. The toolkit includes software services and libraries for resource monitoring, discovery, and management, plus security and file management.

GrangeNet

A high performance research network funded by the Australian Government, through the Advanced Networks Program, to provide the enabling technology for the development of grid and advanced communications services for researchers.

Grid

An information utility that combines hardware, middleware and software resources, from different administrative domains and geographical locations, with a trust federation, allowing authorised users to access, process and store large quantities of data.

High Performance Computing

A branch of computer science that develops and uses the fastest types of computer processors, parallel computers and computer clusters. This discipline includes the development of advanced parallel processing algorithms and software that speeds computing tasks by dividing them into smaller sub-tasks to run simultaneously on separate processors.

ICT Information and Communication Technologies**IMS / GLC IMS Global Learning Consortium, Inc.**

A worldwide non-profit organization that includes more than 50 Contributing Members and affiliates, and develops and promotes the adoption of open technical specifications for interoperable learning technology. The Consortium provides a neutral forum in which members with competing business interests and different decision-making criteria collaborate to satisfy real-world requirements for interoperability and re-use.

Internet2

A consortium led by over 200 US universities working with industry and government to develop and deploy advanced network applications and technologies for research and higher education.

Interoperability

The ability of software and hardware on different machines and networks to share data.

IP Intellectual Property**IPv6**

A new internet protocol designed by the Internet Engineering Task Force (IETF) to replace the current version, Internet Protocol Version 4 (“IPv4”).

IT Information Technology**MAMS Meta Access Management System Project**

A project, funded through the Systemic Infrastructure Initiative and overseen by the Australian Research Information Infrastructure Committee (ARIIC), to develop the software for creating better linkages between university information technology systems. The work is allowing researchers and students to access information more easily and seamlessly from different sources, both within Universities and between Universities. The work is attracting international attention due to successes in developing software for authentication, security and access.

Metadata

Structured data that describes a data resource, (analogous to cataloguing data held by libraries, museums and archives). Metadata aids classification, management, discovery, and use of data by humans or by automated processes. Metadata may include elements representing data attributes such as type, structure, size, title, content, provenance, creation date, author, location, etc.

Middleware

Software that provides standard tools and services to facilitate use of and compatibility across e-Research infrastructure, and to assist e-Researchers to interact with one another.

NCRIS National Collaborative Research Infrastructure Strategy

A major initiative under the Government’s Backing Australia’s Ability - Building our Future through Science and Innovation. It aims to bring greater strategic direction and coordination to national research infrastructure investments. \$542 million from 2004/05 to 2010/11 is available to provide researchers with access to major research facilities and the supporting infrastructure and networks necessary to undertake world-class research.

NSF National Science Foundation

An independent agency of the United States Government that funds approximately 20 percent of all federally supported basic research conducted by America’s colleges and universities.

Ontology

An ontology consists of a list of objects, together with the relationships amongst the set of objects that enhance interoperability between different sources of knowledge.

PB Petabyte

1 Petabyte = 10^{15} Bytes = 1,000,000,000,000,000 Bytes.

Petascale

Computational: Computing capacity in the order of 10^{15} floating point operations per second;

Data Storage: Data storage capacity or data sets in the order of Petabytes in size.

PFRA Publicly Funded Research Agency

PKI Public Key Infrastructure

Policy for establishing a secure method for exchanging information within an organization, an industry, or a nation. PKI is also an integrated set of services and administrative tools for creating, deploying, and managing public-key-based encryption / decryption applications, involving third-party authentication of user identities, through the use of identity certificates.

RD&D Research, Development and Development

Shibboleth

An initiative to develop an open, standards-based solution to the needs for organisations to exchange information about users in a secure manner, Shibboleth is facilitated by Internet2 and a group of leading campus middleware architects from member schools and corporate partners.

SII Systemic Infrastructure Initiative

Announced in 2001 as part of *Backing Australia's Ability*, the SII was a DEST-funded program of \$246 million over five years, to upgrade the systemic research infrastructure resources of universities on a system-wide basis, to support world-class research and research training.

TB Terabyte

1 Terabyte = 10^{12} Bytes = 1,000,000,000,000 Bytes.

Tbps Terabits per second

1 Tbps = 10^{12} bps.

Virtual Organisation

A virtual organisation flexibly and securely shares computing resources, data resources or other information resources in a controlled secure manner across domain or institutional boundaries in order to achieve some common aims of its members.

VPN Virtual Private Network

A network that makes use of public telecommunications infrastructure while maintaining privacy through the use of tunnelling protocol and security procedures.