An e-Research Strategy at La Trobe
An opinion

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Disclaimer: The opinions expressed in this document are those of the author's own. They are in no circumstance represent the views of the current or past employers of the author.

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Executive Summary and recommendations

The author was commissioned by VeRSI (Victorian e-Research Strategic Initiative) to conduct a study in the e-Research options in La Trobe University, one of the members of the VeRSI consortium. The report first considers some of the major components of e-Research, contextualizing them with the current situation in La Trobe University. Then the report considers issues of governance, and human resources and a number of other issues related to e-Research in La Trobe. The report further considers external interactions of La Trobe in the e-Research areas. Finally the report makes some recommendations. These recommendations are indicated as follows:

Recommendations

Short term: upto 12 months

The short term strategies include the following:

1. Communicate with researchers that the e-Research Office will facilitate their e-Research needs
2. Where possible, create collaborative infrastructure to allow groups of researchers to collaborate with one another within the University
3. Assess research strengths within the University on where e-Research may make major impacts
4. Harvest unused processor and storage capacity to provide a "supercomputing" facility to cater for specific needs (either teaching or research)
5. Implement a small computing cluster compatible with the VPAC facilities or NIC facilities so that researchers may "debug" and "tune" their computer programs before deploying them on the VPAC facilities or NIC facilities (this depends if La Trobe users use mainly VPAC facilities or NIC facilities)
6. Implement an institutional repository
7. When the integration of data with institutional repository is mature enough, plan to integrate data into the institutional repository as well
8. Implement an institutional storage facility for research data
9. Formulate policies for the use of these facilities

For some faculties it may require recruitment of internal champions, who would be interested and willing to try out the e-Research methodology. Such champions would need support in terms of personnel who can help them to try out e-Research. In other words, they would need help in making use of databases, integrating them, and help them to demonstrate the potential of such methodology within the Faculty.

Medium term: upto 2 years

The medium term strategies include the following:

1. Communicate and work with researchers on formulating more multi-disciplinary research projects
2. Watch developments in AAF, and be willing to be one of the first to try out their collaborative work space software
3. Federate the storage capacity for research data with those provided by VeRSI
4. With RCAC provide some advice mechanisms and incentive mechanisms for researchers to use the internal computing facility and external computing facilities – this will form a continuum of computing and data storage requirements which can be handled by computing facilities throughout the system (university level, regional, and national levels). In addition, the incentive scheme may extend to provision of grants to provide the needed resources to experiment with the e-Research methodology.
5. Encourage the use of simulation as complementary to hardware experimentation in teaching, as prelude familiarization to actual experiments
6. Implement a version of ARCHER as one way for managing research data and to capture data from experiments (certain subsets of X-ray diffractometers or mass spectrometers)
7. Implement some courses in introducing the concepts of e-Research to senior students and post-graduate students
8. Formulate policies to safeguard the use of services and facilities
9. Experiment on the deployment of visualisation expert
10. Extensive use of video conference facilities as one way of facilitating both teaching and research collaboration among colleagues separated by geographical distances
11. University may consider changing its existing funding models such that incentives are provided for inter-disciplinary and multi-disciplinary research
12. University may consider providing recognition of e-Research workers through a reward and recognition system

Long term: upto 5 years

The long term strategies include the following:

1. e-Research being considered as one of the ways in which research can be conducted
2. Collaborative work space commonly used by researchers both within the University and elsewhere to facilitate close collaborative research
3. Institutional/data repository together with associated policies are implemented
4. Computing requirements are part of the continuum of computing facilities available in the University and elsewhere

5. The University being a node on some of the important and relevant international collaborative research endeavours
6. National scale instruments within the University are accessible by users elsewhere
7. Researchers in the University can access national scale remote instruments
8. Mechanisms are in place to provide incentives for researchers to collaborate across a number of disciplines
9. Mechanisms are in place to provide recognition and reward for e-Research workers

Recommendations for specific discipline

There may be need for specific recommendations related to specific disciplines, e.g. humanities and social sciences. There is much data generated by certain research projects in humanities and social sciences, e.g. education, comparative literature, comparative religion, psychology, education. Such data would need to be "curated" and stored properly on the University's institutional repository. Extensive metadata should be provided so that the data can be searched and re-use by others. This may require specific skills within these disciplines so that they would be able to carry out such work.

1 Introduction

The author of this document was engaged by VeRSI (Victorian e-Research Strategic Initiative) to provide an expert opinion on a strategy on e-Research at La Trobe University. The author spent one week at La Trobe University (17th to 23rd August 2007). During that week, he met with many people in La Trobe University, including the Pro Vice-Chancellor (Research), Director of Information Technology Services, current e-Research Office Director, representative researchers in all disciplines in La Trobe University. Through these discussions, an e-Research strategy was formulated. This report details such a strategy.

The structure of this report is as follows: in Section 2, various components of e-Research will be discussed. In the discussions of these components of e-Research, some commentary and contextualisation on the current situation in La Trobe will be made. The report then considers the governance issues in Section 3. Then, the report considers some human resources and a number of other issues related to e-Research in Section 4. Furthermore the report deals with external relations aspect of e-Research at La Trobe in Section 5. Finally, the report makes a number of recommendations in Section 6.

2 Components of e-Research

A convenient definition and description of e-Research is provided through the following quote from the DEST web site devoted to e-Research.

> The term 'e-Research' encapsulates research activities that use a spectrum of advanced ICT (information and communication technologies) capabilities and embraces new research methodologies emerging from increasing access to:
>
> - Broadband communications networks, research instruments and facilities, sensor networks and data repositories;
> - Software and infrastructure services that enable secure connectivity and interoperability;
> - Application tools that encompass discipline-specific tools and interaction tools.
>
> e-Research capabilities serve to advance and augment, rather than replace traditional research methodologies, but there is a growing dependence on e-Research capabilities. Improved access to knowledge and information will enable researchers to perform their research more creatively, efficiently and collaboratively across long distances and disseminate their research outcomes with greater effect. Using e-Research, researchers can work seamlessly from desk-to-desk within and between organisations.
>
> Entirely new fields of research, hitherto unavailable, are also emerging, using new techniques for data mining and analysis, advanced computational algorithms and resource sharing networks.

From this description of e-Research, it can be surmised that there are a number of key components to e-Research:

- Research collaboration

- Research Infrastructure
- Institutional/data repositories
- Teaching infrastructure

There is a fundamental assumption in the e-Research strategies.

Fundamental Assumption: University network has sufficient capacity both at the backbone and user levels to facilitate fast communication between human and human, human and machine, and machine with machine. Furthermore, the cost of such communication is almost negligible.

In Australia, through the work of AARNet (Australian Academic and Research Network), there is adequate backbone capacity using commercial grade optical fibre network (running at 10 Gbits per second), connecting most main campuses of the universities, at 1 Gbits per second speed. Within universities, most would have sufficient bandwidth for endusers with 100 Mbits per second and, in some cases, 1 Gbits per second connection to the desktop machines. In addition, though the costs of communication charged by AARNet is slightly higher than those charged by wholesale commodity telecommunication carriers, the cost remains affordable, and would not deter users from using the communication links.

In the following subsections, we will provide a discussion of the various components of e-Research.

2.1 Research collaboration

It is well accepted by the research community that some of the most exciting research frontiers lie in the intersections of existing disciplines. It is thus evident that key large interesting and challenging questions in science and technology are often solved by multi-disciplinary and inter-disciplinary research teams. This would require complementary skills and expertise to work on the same problem by these multi-disciplinary teams. For such complementary skills and expertise to work, it will require trust among the researcher team members to work together. It will also require a cultural change among researchers to collaborate with other researchers. This is no doubt the major ingredient in large multi-disciplinary and inter-disciplinary research. There will require the build-up of trust among the team members to work closely together to tackle problems. There will need to be a "common language" among the team members so that they can communicate with one another freely. This "common language" pervades through the interaction among the members, and that they can understand one another (both scientifically and technologically). Both the selection of exciting interesting challenging problems to work on (to match the types of expertise within the University), and the formation of teams to work together to solve these problems would require much thought, and its discussions fall outside the remit of this report, as it will require institutional policies and the articulation, the alignment of common interest and vision to solve the problems at hand. This would require significant amount of work among the researchers, and senior management of the University. Instead, we will discuss the information and communication technology (ICT) ingredients which would facilitate the research among the members. These will be considered in the following subsections.

2.1.1 Collaborative infrastructure

In order to facilitate research collaboration, there would need to be some "secure common" space for researchers to "converse" and interact with one another and to share their "resources". This secure common space would need some kind of authentication mechanism so that researchers would know

that the common space is secure and whatever they discuss will not be known to external parties. This common space is important in engendering interactions among researchers which would be key to good interaction and good communication among the researchers. Such communication would facilitate the solution process of a problem.

At present this is possible through some adaptation of the "wiki" or "plone" technology. A wiki is a software package that enables users to create, edit, and link web pages easily. Wikis are often used to create collaborative websites and to power community websites. These wiki websites are often also referred to as wikis; for example, Wikipedia is one of the best known wikis. A "plone", another software package, claims to not only be a content management system which helps website users with content editing, but it also takes care of a lot of other "behind the scenes" work such as:

- Automatically generate navigation elements
- Making the contents searchable and indexable
- Keeping track of users, their permissions and security settings

Thus a plone does more work for the users than a wiki. However, often wikis and plones do not have any authentication mechanisms as they are designed for open collaborative purposes. Hence there would need to be some incorporation of authentication mechanisms for this to be a "secure common" space for the researchers. There would also need to be some way of forming ad hoc groups as the research team does not necessarily need to be static. Its composition may change from time to time.

As currently there are still some issues with cross institutional authentication, it probably would be easiest to install such a "secure common" work space initially internally within the University before working with researchers externally to the University.

In addition, these work spaces (as implemented by wikis or plones) do not provide convenient ways to share resources easily. The shareable resources among the collaboration team members may include: instruments, data, computing, storage. A common short cut is to share data, which is simplest to share, as researchers can deposit their research data in the common work space, and allow the other researchers to access them. It is far more difficult to share instruments, or computing resources.

In view of the lack of suitable software which could allow researchers to create ad hoc collaborative groups, a temporary solution to create a collaborative workspace within the University would be as follows:

- Create the collaborative group when it is required by ITS
- Create a common space in which they could log in and share data
- Create a virtual presence in which they can communicate with one another through, e.g. personalised video conference facilities (either Personalised Access Grid, or ViaVideo facility.) Note that Skype or Rekatu are not suitable for this purpose as they are known to be insecure for more than point to point communications. The Skype or Rekatu software are based on peer to peer communication technology and hence they would not be secure in general.

A medium-term solution would be to use authentication mechanisms as offered by AAF (Australian Access Foundation). This initiative is funded by the Australian government, and they have a project in providing secure access by researchers across a trusted federated domain. Such a federated domain would allow the easy creation of collaborative groups across institutions in a secure manner.

This project when it is implemented will facilitate the access to a common work space under user control, rather than through central control, e.g. by ITS. It is not difficult to secure such work space. It may however not be possible to share resources, other than information storage for data, within such common work spaces.

It is advisable to facilitate the creation of such secure common workspace for researchers so that they can collaborate with their peers who might not be located next door.

2.2 Research infrastructure

There are a number of possible research infrastructure which might be shared:

- Sharing instruments – There are many occasions in which we might wish to have shared instruments, or to allow remote access to instruments, especially if the instruments are costly or there are only limited number of the instruments in the country. This is difficult at present, because most instruments use proprietary software, which do not normally allow external access to internal data structures. A project like CIMA (Common Instrument Middleware Architecture) may offer one solution to allow data to be captured in instruments and store them in a data storage system for more processing. CIMA currently works with a restricted set of instruments like some X-ray diffractometers, and some mass spectrometers.

  At present it is rare to find instruments which allow remote access and control, except certain specialised instruments, like neutron scattering. It would be ideal to enable most expensive instruments remote presence in which a user can observe the proceeding of the experiments. La Trobe has many expensive and excellent instruments especially in the physical and biological sciences area. It would be ideal if some of these instruments could be made available to users within La Trobe through remote presence.

  Data captured from the instruments can be categorised, and provided with metadata so that they are searchable, and shareable within the collaborative group. This is the aim of the DART/ARCHER project (a project funded by DEST, the host institution is Monash University), to provide ways in which data captured from instruments can be accessed, and published. By mid-2008, there should be a version of ARCHER which can link up to particular brand of X-ray diffractometer, capture the data, put them in designated storage, and allow the users to remote access to the data. It is unknown if ARCHER or any continuation project will expand the instrument capturing facility to other instruments, though the CIMA software would be available by then for others to try to link their instruments up to this software suite.

  There are large national instrument facilities, e.g. synchrotron, neutron scattering, in which users might wish to access. VBL (Virtual Beamline) from VeRSI is an excellent initiative in this direction. It simulates the functions of a beamline on the synchrotron, and it facilitates users to familiarise with the operation of the synchrotron. It may be useful to consider other possibilities, like "virtual neutron scattering". La Trobe University would have access to the VBL, as well as the synchrotron. Indeed La Trobe scientists are some of the forerunners for some of the facilities offered by the Australian Synchrotron. It would be advisable for La Trobe scientists to take full advantages of this, and to ensure that the remote presence function to the Synchrotron would work.

  As the NCRIS process matures, more and more national instruments will be accessible over the Internet. It would be important that the University to have the capacity to access these facilities,

may be initially through a remote presence process, and later through remote access. This will facilitate users within the University to gain access to these national facilities remotely.

- Computing on demand – It is quite simple to "harvest" unused processing power and storage e.g. in computing laboratories, during off-peak periods, and turn them into a consolidated supercomputing facility. This computing facility can be made available to researchers without additional expense to the University. Using specialised software, it is possible to schedule jobs on such "harvested" computing power, and perform computational tasks. However, this type of computing capability "harvested" from individual workstations is only suitable for certain type of computing problems (coarse grain computational problems).

  For fine grain computational problems, researchers can use VPAC or NCI (National Computational Infrastructure, or whatever it will be called in the future) facilities. Such computing resources are shared with other users, and used within a certain pre-assigned allocated quota. Since quota is "limited", it would be useful for the University to have its own small cluster, preferably compatible with either the one in VPAC or the one in NCI, so that researchers can "debug" and "tune" their programs before deploying them on VPAC or NCI facilities.

  It is also useful to add a note here on visualisation. Data will be available in such quantities that it will be physically impossible for researchers to "eyeball" them. Some forms of visualisation would be important to help users to visualise their data. It is however not advisable to have high end visualisation facility installed, as most of these would require specialised attention (often by a full time technician). However to help researchers with their visualisation need, it would be useful to consider the possibility of having a "roaming" visualisation consultant available to help users to visualise their data on their desktop or high end desktop visualisation facility.

- Storage on demand – It would be useful to have separate storage facilities, from the University administration storage facilities, for researchers. This will provide them with the capacity to store data as well as metadata and to allow the data to be searchable, and retrievable by other researchers. Such storage facility can be a federated one with the rest of VeRSI (storage facilities located physically elsewhere but can be configured to be logically one storage facility). This will provide the researchers at La Trobe University with adequate storage facilities. In addition, where the researchers would wish their data to be re-used by others, they can provide the metadata and make it available so that the dataset is searchable and can be re-used by others.

2.3 Institutional/data repositories

Institutional repository is the storage and retrieval of research outcomes [1], like publications, preprints of a unit or an institution. So far deposition of research outcome at most institutional repositories are voluntary in nature, in that authors can elect to provide links to publications or preprints or to upload their research outcomes. Few institutions have policies in place which require the mandatory deposit of research outcomes in institutional repositories.

It may be useful to consider institutional repositories as one way of knowledge management within an institution. This will require integration of institutional repositories with other administration systems, e.g. human resources, finance, to form a comprehensive knowledge management system. In such a system, the outcomes of research can be stored in an institutional repository. Such outcomes

[1] In this report, research outcomes are much wider than publications. They will include: publications, data, video, images, audio, images of sculptures, images of paintings. In other words, research outcomes refer to the outcomes of research or scholarly work which emerge from staff's research and scholarly efforts.

can include data, video, computer programs, instruction manuals. A staff is asked to submit their research outcomes in the institutional repository on a regular basis or as soon as their research outcome is available. Hence the institutional repository becomes a way in which knowledge generated by staff and their associated process is retained within the institution. Such practice is not restricted to only publications, which is the case with most institutional repositories. Research outcome can include: data, videos, computer programs, audio recordings, sculptures (images taken from various angles, or from a three-dimensional scanner), music performances, etc. This will also require policies for mandatory deposition of research outcomes, and their safeguard for future use.

As indicated previously, it would be very useful to include data as part of institutional knowledge management scheme. Such data will be linked to research outcomes, and become searchable. The data can also be linked with internal process in the capture and management of data from experiments, or processes. This will require comprehensive policies in the University for data management for this to work.

It would be useful if research outcomes are provided with metadata so that they are searchable, and retrievable by other researchers. Such research outcomes can then be shareable with other researchers within the same institution. This will require policies to safeguard the use of information stored in institutional/data repositories, both now and for the future. In certain cases, this may allow users outside the institution to access research outcomes and the associated data, through a national federated data repository system

If such a system is in place this will also ensure the research integrity of the institution as the raw data is available, if there is any dispute or doubt about the authenticity of data obtained. However, this will require further safeguard so that any modification to the raw data is traceable at a future date.

2.4 Teaching infrastructure

While e-Research is not explicitly related to teaching, there are instances in which teaching infrastructure may be deployed alongside e-Research infrastructure. In e-Learning there may be occasions in which simulation of laboratory experiments are called for. Such simulation, e.g. chemistry experiment simulation, especially if the simulation is realistic built up from the molecular level, may require significant computing power over a short period.

By pooling together unused processor power (in computing laboratories), it may be possible to handle surges in computing demand due to intense simulation requirements by harvesting unused processor power within the University. This would avoid the need to install large specific processors in the e-Learning system to handle such requirements. Obviously this makes the assumption that the simulation can be carried out by coarse grain computational techniques. In cases where the simulation needs to be carried out by fine grain computational techniques, a tightly connected set of processors (cluster computer) will still be required.

It would also be useful to establish course work for, perhaps, Honours or Masters students covering information management/e-Research for researchers. Through such courses at this level, we can influence the new generations of students (and some of them will become new researchers in the future) to be more aware of how advanced ICT can assist, particularly in their research activities. It might be useful to mandate that senior students in their undergraduate degree courses, and postgraduate students in all disciplines to take such a course so that they will be familiar with the concepts of advanced ICT and e-Research.

Secure video conference facility may be one way to overcome the distance in a distributed campus environment like La Trobe. It is possible to make more use of Access Grid facility to facilitate remote communications among the various campuses of La Trobe University. It may be possible also to

use Access Grid facilities to provide remote presence to instruments, so that researchers do not need to travel extensively. This will also save considerable amount of money for the University as the University does not need to install duplicate instruments in various campuses.

3 Governance

There is already in existence RCAC (Research Computing Advisory Committee) in La Trobe University. RCAC advises the ICTPC (Information and Communication Technology Policy Committee) on the requirements of research computing, and more in general e-Research requirements. The ICTPC is the top governing committee advising the Vice-Chancellor on ICT needs of the University. The governance structure is adequate and can be used as a vehicle in guiding the embrace of La Trobe University in e-Research, and can determine the types of facilities which are required for La Trobe to further its ambition as one of the leading universities in Australia.

3.1 Policies

There will be a number of policies which relate to e-Research. These include:

- Information policy
- Computing using "harvested" resources policy
- Collaborative space policy
- Research collaboration policy
- Long term storage of research outcome policy
- ...

These will require significant amount of work by the RCAC and ICTPC to formulate these policies and to ensure that the University adheres to these policies.

4 Human resources and other issues

In multi-disciplinary research endeavours, it will require a cultural change among researchers to collaborate and share resources with others. This cultural change can take place naturally, as researchers gradually gain the confidence and the skills to collaborate or share resources with other researchers. In this case, chances are that it will take considerable time for this to be absorbed as the prevailing culture. The cultural change however could be hastened if the University provides incentives to hasten its happening. This cultural change may also require the current funding model for research within the University to be adjusted to provide incentives for researchers to collaboratively work together.

University may consider employing a cultural change agent to help researchers to change their attitudes to collaborate with others. This cultural change agent can be part of the role of an e-Research Office director, an additional person or additional persons skilled in change management. This change agent would be critical in helping the researchers to accept the idea that to tackle challenging and exciting problems in science and technology, multi-disciplinary research and in collaboration with other researchers would be the norm rather than the exception. The change agent would then work

with the researchers so that they would accept such change in circumstances and to excel in this role. This in combination with policies and the adjustment of funding models will hasten the adoption of e-Research, and would also engender multi-disciplinary and inter-disciplinary research within La Trobe, thus facilitating it to achieve its ambition as one of the leading universities in Australia.

4.1 Champions

There would need to be a champion for the cause of e-Research within the University. This person or persons would need to have the respect of the academic community (and may be an academic himself or herself, either currently or in the past). This person or persons would be seen as the person(s) promoting and persuading researchers of the virtue of e-Research and the need to adopt e-Research as a methodology in research. Ideally there should be a champion at the University level, faculty level and departmental level. This person or these persons could be part of the e-Research Office. The person at the University level could be part of the role of the e-Research Office director, or could be a separate person. Similarly the person at the faculty level or departmental level could be the Dean (head of department) or a separate person. The champion or champions can be full time or part time positions. This would depend on whether there are such persons within La Trobe University, and whether such persons would be willing to take up such tasks. At the faculty or departmental levels, the champions would be seen as "trail brazers" in that they are the early adopters or pioneers of e-Research and can provide examples of applications of e-Research within their own discipline's orientation.

4.2 e-Research workers

It will be important for the work of e-Research workers to be recognised and rewarded appropriately. There will be a number of highly skilled e-Research personnel within the University as the University progressively adopts e-Research as a methodology as one way of conducting research. Their contribution to the University will need to be recognised appropriately, otherwise there may not be the type of talent which would need to be among e-Research workers. Ideally a career structure would need to be provided so that such persons can progress with their career within the University. Such career structure may be part of the academic career structure, i.e. for some e-Research workers, they would be considered as academics and hence their performance and advancement within the University is evaluated using academic standards (mainly through their research outcomes, quality of teaching and services), while some e-Research workers are more technically oriented, and hence their career structure may adhere to that of the administrative and service staff (mainly evaluated on the competency in carrying out the tasks, and in technical leadership). It would be important to have a well defined career structure for e-Research workers so that it will attract some of the best talent into the services of e-Research in La Trobe University.

5 External interaction

So far the above considerations concentrate on internal environments. There will need to be, in addition, interaction with external agencies, sources of funding, etc. The e-Research Office established in the University will be an ideal vehicle to carry out such tasks. It may serve as a bridge between internal and external entities in e-Research matters.

The e-Research Office can interact with VeRSI on a Victoria-wide e-Research initiative and to ensure that La Trobe researchers can tap into the various projects which are ongoing within VeRSI

and elsewhere. The e-Research Office can interact with NCRIS, specifically through AURIC (NCRIS 5.16) and its various umbrella committees for e-Research infrastructure.

The e-Research Office can interact with other e-Research offices in the country to ensure that it is well informed of the initiatives taken place elsewhere. The e-Research Office would need to have extensive internal "promotion" (champions) of e-Research and may act as a change agent in bringing about changes to the research culture within the University.

The e-Research Office should work closely with ITS in providing the e-Research infrastructure to researchers; the Library in providing the information management aspects of e-Research. The e-Research Office should liaise with other e-Research initiatives globally to ensure that La Trobe researchers are well aware of initiatives taken place elsewhere, and where possible and relevant, to be part of the international initiatives.

From this discussion, it is clear that the e-Research Office would be a critical vehicle in which the University can use to promote and to facilitate the adoption e-Research within the University.

6 Recommendations

In this section we will outline the recommendations to the University on e-Research. These are separated into three sections:

- Short term, within the next twelve months horizon
- Medium term, between one and two years horizon
- Long term, between three to five years horizon

The detailed recommendation would be provided in the following subsections.

6.1 Short term

The short term strategies include the following:

1. Communicate with researchers that the e-Research Office will facilitate their e-Research needs
2. Where possible, create collaborative infrastructure to allow groups of researchers to collaborate with one another within the University
3. Assess research strengths within the University on where e-Research may make major impacts
4. Harvest unused processor and storage capacity to provide a "supercomputing" facility to cater for specific needs (either teaching or research)
5. Implement a small computing cluster compatible with the VPAC facilities or NIC facilities so that researchers may "debug" and "tune" their computer programs before deploying them on the VPAC facilities or NIC facilities (this depends if La Trobe users use mainly VPAC facilities or NIC facilities)
6. Implement an institutional repository
7. When the integration of data with institutional repository is mature enough, plan to integrate data into the institutional repository as well

8. Implement an institutional storage facility for research data
9. Formulate policies for the use of these facilities

For some faculties it may require recruitment of internal champions, who would be interested and willing to try out the e-Research methodology. Such champions would need support in terms of personnel who can help them to try out e-Research. In other words, they would need help in making use of databases, integrating them, and help them to demonstrate the potential of such methodology within the Faculty.

6.2 Medium term

The medium term strategies include the following:

1. Communicate and work with researchers on formulating more multi-disciplinary research projects
2. Watch developments in AAF, and be willing to be one of the first to try out their collaborative work space software
3. Federate the storage capacity for research data with those provided by VeRSI
4. With RCAC provide some advice mechanisms and incentive mechanisms for researchers to use the internal computing facility and external computing facilities – this will form a continuum of computing and data storage requirements which can be handled by computing facilities throughout the system (university level, regional, and national levels). In addition, the incentive scheme may extend to provision of grants to provide the needed resources to experiment with the e-Research methodology.
5. Encourage the use of simulation as complementary to hardware experimentation in teaching, as prelude familiarization to actual experiments
6. Implement a version of ARCHER as one way for managing research data and to capture data from experiments (certain subsets of X-ray diffractometers or mass spectrometers)
7. Implement some courses in introducing the concepts of e-Research to senior students and post-graduate students
8. Formulate policies to safeguard the use of services and facilities
9. Experiment on the deployment of visualisation expert
10. Extensive use of video conference facilities as one way of facilitating both teaching and research collaboration among colleagues separated by geographical distances
11. University may consider changing its existing funding models such that incentives are provided for inter-disciplinary and multi-disciplinary research
12. University may consider providing recognition of e-Research workers through a reward and recognition system

6.3 Long term

The long term strategies include the following:

1. e-Research being considered as one of the ways in which research can be conducted
2. Collaborative work space commonly used by researchers both within the University and elsewhere to facilitate close collaborative research
3. Institutional/data repository together with associated policies are implemented
4. Computing requirements are part of the continuum of computing facilities available in the University and elsewhere
5. The University being a node on some of the important and relevant international collaborative research endeavours
6. National scale instruments within the University are accessible by users elsewhere
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8. Mechanisms are in place to provide incentives for researchers to collaborate across a number of disciplines
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6.4 Recommendations for specific discipline

There may be a need for specific recommendations related to specific disciplines, e.g. humanities and social sciences. There is much data generated by certain research projects in humanities and social sciences, e.g. education, comparative literature, comparative religion, psychology, education. Such data would need to be "curated" and stored properly on the University's institutional repository. Extensive metadata should be provided so that the data can be searched and re-use by others. This may require specific skills within these disciplines so that they would be able to carry out such work.