



Open source software and Australian school education

An introduction

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INTRODUCTION

Open source software uses software source code that is open, unrestricted and available by downloading it from the Internet. The 'open' in open source software is intended in the philosophical sense of 'open or free speech' rather than as a free (ie no cost) product. The code in open source software is available and viewable. Open source software is developed by identifiable communities who contribute to the development of a particular piece of software. People in the software communities participate voluntarily or are paid by employers such as government departments or companies such as IBM, Hewlett Packard and Sun Microsystems. The open source software itself is made available to the public at large as a public good rather than for gain or profit. Companies such as RedHat achieve financial gains related to open source software from the research developed through the collaborative processes which underpin open source software development, and from associated products such as the packaging of products, associated technical services, conferences, books, and promotional materials.

There are several business uses and software platforms available in the marketplace. Questions concerning whether to include open source software within the IT portfolio of a school or school sector tend to revolve around balancing four differing demands: the business case; technical demands; legal requirements; and ethical, social and educational implications. The choices of software schools and sectors make are based upon a range of issues; much of which involve weighing the risks against the benefits about the purposes to which the software is to be put. Formally constructed financial analyses of the costs and benefits of software, along with the applicability of the software for a particular organisation are referred to as 'total cost of ownership' reports. There is no research pertaining to Australian schools concerning the total cost of ownership of using open source software, and such work was outside the remit of this paper. In the absence of Australian research, this paper provides an overview about open source software and includes information from government and other formal reports drawn from around the world.

Governments and schools are interested in increasing the interoperability between software systems for teaching and learning and administrative purposes. The question of how to achieve interoperability hinges on the nature of the standards upon which the software is based. This is akin to determining the nature of the foundations upon which a house is to be built. Open standards that allow the standard to be seen, provides the capacity for interoperability between both open and proprietary software. Open source software provides a concrete way of developing open standards. Rather than making open standards theoretical exercises, open source software provides the practical means for determining these standards.

The issues around whether open source software has a place in a school or sector's IT portfolio can tend to draw emotive responses, yet the questions do not require 'either/or'; or 'one versus the other' responses. Software infrastructure in schools and sectors for the most part are not 'green field sites', and so the choices about the acquisition and provision of software similarly are not black and white; either/or decisions.

This paper provides an introduction to open source software in the context of Australian schools. It is intended to provide the basis for developing some shared understandings about what open source software is; its benefits; its limitations; and it provides a brief scan of what is happening in Australian schools and sectors. This paper may provide the basis for informing future discussions at state and national levels.

CONTEXT

There are several contexts that require consideration in order to discuss open source software and Australian school education. To set the scene the following contexts are outlined:

- Terminology
- Learning architectures: schools and software
- Software: a building block of learning architectures
- How software is created
- The software market.

These contexts are discussed here in turn, as a prelude to outlining what is open source software.

Terminology

Terminology around different sorts of software can be confusing. At the outset then, some clarification of terms is provided. Here distinctions are made between the terms 'freeware', 'shareware', 'public domain software', 'proprietary software' and 'open source software'.

Freeware is a vague term and is avoided in this paper. It is usually used when a piece of software is given at no cost, even if the programs are released only as executables, with their source code not available. For example, you can download the Adobe Acrobat Reader as freeware, but the software is still proprietary. The same applies to all terms related to the price of the software as 'give away software' or 'sell software'.

The term *Shareware* also covers a sales concept. *Shareware* is software that is usually distributed free of charge for a limited period of time or for a limited use, mainly to give the user the opportunity to test it before buying it.

Public domain software is software for which copyrights do not exist. The phrase *Public domain software* is often used for software any one can use for any purpose, without any restriction. In addition, the availability of the source code is not granted. *Proprietary software* generally provides limited rights to use a product, sometimes on a specific machine, sometimes with a specific power or processor, sometimes with a limited number of signed or concurrent users, or related to a limited amount of material.¹

Open source software is software that has source code that is open, viewable, unrestricted and redistributable, and is available by downloading it from the Internet.

In introducing open source software it is difficult not to make comparisons with proprietary and commercial off-the-shelf (COTS) software, although this has been kept to a minimum throughout the paper.

Learning architectures: schools and software

Traditionally the infrastructure for schooling has been the provision of school buildings, or where the access by students to these buildings has not been possible, distance education has been provided. With the increasing use of computers in schools 'learning architectures' are emerging. The MCEETYA ICT in Schools Taskforce policy statement *Learning Architecture: Learning in an Online World (2003-06)* encourages a planned ICT

¹ These definitions are drawn from P. Schimitz & S. Castiaux, Pooling open source software: An IDA Feasibility study – Interchange of data between administrations, European Commission, 2002

framework that comprises hardware, software and people². 'Learning architectures' provide the infrastructure to enable the school sector to share information internally and with external organisations. Schools then not only require all the traditional infrastructure requirements, they now also require access to computer hardware and software and access to the Internet. The provision of these electronic services brings with them increased demands on electricity; and requires access to affordable and robust telecommunications services. Local and wide area networks or virtual private networks are necessary if students, teachers and other personnel are to electronically communicate across schools and between schools; between schools and homes; and between schools or home and support offices and central offices.

Around Australia, schools are encouraged to use ICT in their daily work. Broadly and briefly, these technologies are being used in schools and sectors in several ways, including the following:

- incorporating ICT as part of classroom practice in 'face to face' schools (reception to year 12) both as an area of curriculum content in itself (eg the development of computer skills) and as a teaching and learning methodology (eg teaching students how to use the Internet as a research tool);
- linking specific skill training and formal vocational qualifications with senior secondary state and territory accredited qualifications, and within the states and territories respective benchmarking strategies;
- using ICT as a communication tool to overcome barriers of demographics and geography such as how it is used in distance education;
- supporting teacher professional development activities, (eg through online forums);
- using ICT as part of the work of the library both as an administrative tool for librarians and for reference and research use by students;
- underpinning the daily administrative work of the school, (eg maintaining school records such as financial records, timetables, and attendance rolls across a school);
- supporting individual teacher's work whether that is curriculum development, classroom planning, student assessment and reporting, administrative responsibilities and time management requirements, or communication between staff, students and parents across the school community; and
- providing information to the interested public and to school staff through the use of websites and portals.

Software: a building block of learning architectures

One building block of learning architectures is software: all computers and networks of computers require software to work. There are two main sorts of software: the systems software or operating system (OS), which controls the workings of the computer; and the application software that allows computer users to undertake specific sorts of tasks such as word processing, using spreadsheets or developing and manipulating graphics.

No software applications will work on a computer without an operating system. Operating systems are used for making individual computers work as well as for making networks of computers work. That is, local and wide area networks are as dependent on a reliable operating system as is an individual personal computer (PC). Examples of proprietary operating systems are Windows and Windows NT. Examples of open source operating systems are Linux and FreeBSD.

At the desktop or 'front end' of computers, users interact with a variety of applications software. Examples of proprietary applications software includes the Microsoft® Office suite of products. Examples of open source office applications software are OpenOffice and StarOffice.

² MCEETYA ICT in Schools Taskforce Learning Architecture: Learning in an Online World (2003-06), Curriculum Corporation 2003, p5

Web applications are software used to provide access to the Internet. Much Internet software is open rather than proprietary. Microsoft's browser Internet Explorer uses proprietary software. Examples of open source software employed on the Internet include:

- Sendmail: the program that routes over 90% of all email on the Internet;³
- Perl: the programming language that allows dynamic features on many websites;⁴
- Apache: the most popular web server software in use on the Internet;⁵
- BIND (the Berkeley Internet Name Daemon): the de facto DNS (Domain Name System) server for the Internet;⁶
- Mozilla: the open code software used in the Netscape browser.⁷

To support distributed, networked computing environments middleware is used. The term 'middleware' refers to the set of services, the major components of which are identification, authentication, and authorization (IAA). Microsoft's Active Directory and Novell (NDS) are examples of proprietary middleware software and standards. The Lightweight Directory Access Protocol (LDAP) provides an open protocol and open-source solution for implementing the identification component of the middleware process.⁸

The open source software SAMBA supports interoperability. Originally developed in Australia and supported by the Australian National University, SAMBA allows computers to share files between proprietary and non-proprietary software. That is, SAMBA allows open and closed software to work together.⁹

How software is created

Software is created by people. People write software programs to enable themselves and other people to use computers to communicate with each other in a variety of ways: through document and presentation development, via email, and through using rich multimedia on CD, DVD and over the web. Schools and school systems commission software development (eg student reporting; human resource and payroll systems) as well as purchase off the shelf products (eg Microsoft Office). Irrespective of the nature of the software and its purpose, software is socially constructed. To make an operating system and other software work requires programming. To program requires the use of a language.¹⁰ These are known as programming languages: the languages in which the authors write the commands required to make computers work the way they want them to do. Anyone with the skills to understand the languages of programming can create software. Communities of developers communicate with each via the Internet to create software. Programmers are also employed by vendors to develop software for sale.

³ See C. Kenwood, A Business Case Study of Open Source Software, MITRE, 2001, pxii, http://www.mitre.org/support/papers/tech_papers_01/kenwood_software; Sendmail: <http://www.sendmail.org>

⁴ See Open Source Initiative, Products, Open Source Initiative, 2001a, <http://www.opensource.org/docs/products.html>

⁵ See Board of Technology, Government of Denmark, Open-Source Software in Digital Management in the Public Sector, Government of Denmark 2002

⁶ See Open Source Initiative, Products, Open Source Initiative, 2001a, <http://www.opensource.org/docs/products.html>;

⁷ See E. Raymond, Cathedral and the Bazaar. Musing on Linux and open source by an accidental revolutionary, O'Reilly, USA 2001

⁸ See Wettstein & Grosen, *Gaining the middleground: A Linux-based open source middleware initiative*, Proceedings 4th Annual Linux Showcase and Conference, Atlanta USA, October 10-14 2000; Distributed Systems Online, Middleware, 2003 <http://dsonline.computer.org/middleware>

⁹ See C. Kenwood, A Business Case Study of Open Source Software, MITRE, 2001, pxii, http://www.mitre.org/support/papers/tech_papers_01/kenwood_software; Australian National University, <http://samba.anu.edu.au/samba/> and <http://au1.samba.org/samba/samba.html>

¹⁰ E. Raymond, Cathedral and the Bazaar. Musing on Linux and open source by an accidental revolutionary, O'Reilly, USA 2001, pix-x

The software market

The acquisition of software by schools has tended to be reliant on the market. The software environment is not static which can make purchasing software an activity that draws considerable attention from a range of sources. Commercial software companies move to innovate rapidly to maintain a market-edge over competitors. For example, by gaining a market niche for a particular piece of software provides vendors with the opportunity to establish their IT standards for that work.¹¹

WHAT IS OPEN SOURCE SOFTWARE?

Source code is the language used by programmers to create software. Open source code means the code is available. Open source software uses source code that is open, unrestricted and freely available by downloading it from the Internet.¹² The 'open' in open source software is intended in the philosophical context of 'open or free speech' rather than as a free (ie no cost) product.¹³ Open source software forms the basic infrastructure of the Internet.¹⁴ As open source software is publicly accessible and viewable it promotes interoperability.¹⁵

Without a fee, open source code can be moved around by those with sufficient expertise, to fix bugs and customise software, so that the software meets the specific demands placed on it. As such, open source software can be structured to meet organisational requirements.¹⁶

Open source software both encompasses a philosophy about the way software is produced; and at the same time is a product with a particular licensing agreement associated with that product. Diagram one illustrates two major facets of open source software.

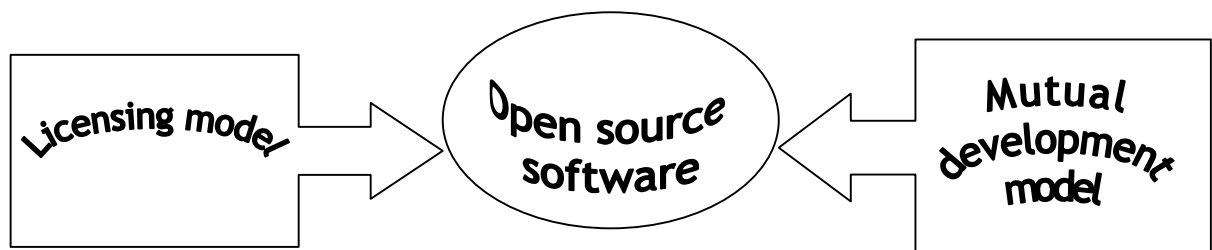


Diagram 1: Two major facets of open source software

Mutual development

The basic idea underpinning open source software is that when programmers and technicians can create, read, modify and redistribute the source code of a piece of

¹¹ See R. Gehring, *Software development, intellectual property, and IT security*, Journal of Information, Law and Technology, 1, 2003, <http://elj.warwick.ac.uk/jilt/03-1/gehring.html>

¹² Open Source Initiative, The open source definition, Open Source Initiative, 2001b, <http://www.opensource.org/docs/definition.html>

¹³ *Ibid*; See NSW Department of Commerce, Office of Information Technology (OIT), Open source software, 2003, <http://www.oit.nsw.gov.au/pages/1.7.news.html>

¹⁴ See C. Kenwood, A Business Case Study of Open Source Software, MITRE, 2001, pxii, http://www.mitre.org/support/papers/tech_papers_01/kenwood_software ;

¹⁵ See Board of Technology, Government of Denmark, Open-Source Software in Digital Management in the Public Sector, Government of Denmark 2002; C. Kenwood, A Business Case Study of Open Source Software, MITRE, 2001, http://www.mitre.org/support/papers/tech_papers_01/kenwood_software

¹⁶ See Open Source Initiative, The open source definition, Open Source Initiative, 2001b, <http://www.opensource.org/docs/definition.html>; Board of Technology, Government of Denmark, Open-Source Software in Digital Management in the Public Sector, Government of Denmark 2002

software, then the software evolves: people improve the software; adapt it and people fix the bugs in it.¹⁷

Open source software evolves as a result of 'many eyeballs'¹⁸ viewing the software, testing it, debugging it and contributing the improved software back to the software community. IBM is a recognised and trusted member of the Linux community.¹⁹ Gartner's research²⁰ indicates that IBM and SGI have made major contributions to the Linux community by making improvements to the Linux operating system, in particular in relation to Linux storage volume management and in strengthening the Linux file system. Fujitsu, Hitachi, IBM and NEC have contributed to the development of better tools for analysing Linux performance and troubleshooting Linux kernels.²¹

Licences

When open source software is downloaded from the Internet the users of that software are required to adhere to the licence agreements of the software. Licences for open source software provide an unconditional right of any party to modify and redistribute the software for free.²² The copyright of open source software belongs to the author rather than the vendor. The licences are premised on a view originally forwarded by Richard Stallman that people should have more freedom in software construction and use. As such he designed and codified a set of users' rights for open source software that he named 'copyleft' because the right to copy was left in place.²³

There are a variety of open source software licences but they are all premised on the author (the 'licensor') giving some fundamental freedoms to the user (the 'licensee') inside a licence agreement. These freedoms are:

- the freedom to study how the program works
- the freedom to access the software code
- the freedom to modify the code according to specific requirements
- the freedom to run the software for any purpose on any number of machines
- the freedom to redistribute copies of the software to others.²⁴

Examples of open source software licences are

- the GNU General Public License (GPL)
- the GNU Library or 'Lesser' Public Licence
- the BSD License
- the Mozilla Public License.²⁵

The Open Source Initiative has collected copies of various open source licences. The Open Source Initiative is a non-profit corporation that manages and promotes open source software licences by providing certification of these licences and hosts the details of the licences on its website.²⁶

¹⁷ See Open Source Initiative, [opensource.org](http://www.opensource.org), Open Source Initiative, 2001c, <http://www.opensource.org>

¹⁸ E. Raymond, *Cathedral and the Bazaar*. Musing on Linux and open source by an accidental revolutionary, O'Reilly, USA 2001

¹⁹ See M. Fisher, *Open source software and the role of Linux in the public sector*, IBM, 2003

²⁰ M. Hubley & N. Muller, *Linux: What major IT vendors are doing*, Gartner, 2002, <http://asiapac.gartner.com/events/noie.cfm>

²¹ *Ibid*

²² *Ibid*

²³ See GNU Project, *What is copyleft*, 2003, <http://www.gnu.org/copyleft.html>; UNESCO, *UNESCO Free Software Portal*, 2001, http://www.unesco.org/webworld/portal_freesoftware/Software

²⁴ See P. Schimitz & S. Castiaux, *Pooling open source software: AN IDA Feasibility study – Interchange of data between administrations*, European Commission, 2002, <http://europa.eu.int/ISPO/ida/export/files/en/115.pdf>

²⁵ See Open Source Initiative, *The approved licenses*, Open Source Initiative, 2001, <http://www.opensource.org/licenses/index.html>

²⁶ See Open Source Initiative, [opensource.org](http://www.opensource.org), Open Source Initiative, 2001d, <http://www.opensource.org>

OPEN AND CLOSED SOFTWARE

The main software the Australian states and territories purchase is developed by Microsoft® Corporation.²⁷ It uses closed source code. Closed source code means that while skins and macros can be used to make cosmetic changes to the look and feel of the software, the code cannot be opened, viewed, customised or reauthored to meet specific requirements of individual locations nor can it be manipulated in order to fix bugs without paying Microsoft® Corporation for the rights to make such changes to the code.²⁸ Failure to abide by the requirements placed by the vendor on the customer has potentially punitive consequences including the risk of being sued for breach of the licensing agreement. Closed source code by its very nature (that is, being closed), therefore generates more restrictive uses of software.²⁹ This sales approach to software is akin to buying a car but not being able to open the bonnet to look at the engine or to fix things in the engine without gaining permission from the original vendor.

Open source software leaves in place the right to read, redistribute and modify the software.³⁰ There are different levels at which adaptation and modification of open source software can occur. A piece of open source software can be downloaded from the Internet. If this piece of software does most but not all required of it within a local context then the software can be modified and improved at that local level without any risk of being sued.³¹ These modifications can remain at the local level or the changes can be posted back to the software development group. The software is publicly peer-reviewed³² among the open source community and then, if accepted by the development group is posted to the Internet. Only the best code gets selected to amend earlier code.³³

The following three examples show how open source software communities work:

The Apache web server is freely available from the web. It has an open source licence. Members of the Apache team form a voting committee and this committee sets the directions of the Apache project. The Apache Software Foundation provides organisational, legal and financial support for Apache products.³⁴

Linux is an open source operating system. The kernel of the software is maintained by the Linux community, led from Finland by Linus Torvalds, the creator of Linux. There is a global team of delegates responsible for managing certain areas of the project and in turn each of the have a team of coordinators.³⁵

²⁷ K. Moyle, Using open source software in government schools and the implications for policy, EduCause Australasia, EduCause, Adelaide May 2003a, pp1-11

²⁸ See C. Zymaris, A comparison of the GPL and the Microsoft EULA, Cybersource 2003, http://www.cybersource.com.au/cyber/about/comparing_the_gpl_to_eula.pdf;

²⁹ *Ibid*; R. Gehring, *Software development, intellectual property, and IT security*, Journal of Information, Law and Technology, 1, 2003, <http://elj.warwick.ac.uk/jilt/03-1/gehring.html>

³⁰ See Open Source Initiative, opensource.org, Open Source Initiative, 2001c, <http://www.opensource.org>

³¹ See Board of Technology, Government of Denmark, Open-Source Software in Digital Management in the Public Sector, Government of Denmark 2002

³² See M. Hubley & N. Muller, Linux: What major IT vendors are doing, Gartner, 2002, p5 <http://asiapac.gartner.com/events/noie.cfm>

³³ See M. Fisher, Open source software and the role of Linux in the public sector, IBM, 2003; C. Kenwood, A Business Case Study of Open Source Software, MITRE, 2001, http://www.mitre.org/support/papers/tech_papers_01/kenwood_software; E. Raymond, Cathedral and the Bazaar. Musing on Linux and open source by an accidental revolutionary, O'Reilly, USA 2001;

³⁴ C. Kenwood, A Business Case Study of Open Source Software, MITRE, 2001, xi-xii, http://www.mitre.org/support/papers/tech_papers_01/kenwood_software

³⁵ C. Kenwood, A Business Case Study of Open Source Software, MITRE, 2001, xii, http://www.mitre.org/support/papers/tech_papers_01/kenwood_software

Practical Extraction and Reporting Language (Perl) is a system administration and computer programming language used throughout the Internet. Perl is managed on a rotating basis by a team of active programmers. Each takes turns in managing different parts of the project.³⁶

The open source model of software development, review and use provides a basis for ensuring the security and robustness of the kernel of the software is maintained. At the same time software is produced and de-bugged, while providing the ability for enabling local level manipulation of the software's deployment to be left in place.³⁷ The open source software models offer governments the ability to download and use open source software and then write (or commission the writing) of their own specific encryption and security coding. Governments such as the Danish government see such an approach as providing them with the ability to reduce the costs of the software while improving the security.³⁸ Such an approach requires only writing the security code rather than the full piece of software and the security code, and unlike off-the-shelf products, is one specific to the local requirements.³⁹

OPEN STANDARDS AND OPEN SOURCE SOFTWARE

Open standards form the basis for stability and interoperability of software systems.⁴⁰ Open standards provide clear, public and viewable descriptions of data and behaviour.⁴¹ Open standards differ to defacto or proprietary standards since users and standards bodies (eg World Wide Web Consortium (WC3), IMS and Object Management Group (OMG))⁴² evolve and control open standards. Open standards underpin the operations of different software systems' ability to exchange information, which is referred to as interoperability. Open standards allow different pieces of software to act in complementary ways. Open standards mean that users are not locked in to any one specific software system. Through the specification and use of open standards, one standards-compliant system can be linked with or substituted by another standards-compliant system.⁴³ Open standards can be implemented by proprietary as well as open source systems provided that all the software systems adhere to the same standards.⁴⁴ In other words the use of open standards enables open and closed software environments to be combined.⁴⁵ Open formats in which to store data increase the likelihood for the long-term readability of electronic data.⁴⁶ Through the development and use of publicly viewable code, open

³⁶ C. Kenwood, A Business Case Study of Open Source Software, MITRE, 2001, pxii-xiii, http://www.mitre.org/support/papers/tech_papers_01/kenwood_software

³⁷ See Board of Technology, Government of Denmark, Open-Source Software in Digital Management in the Public Sector, Government of Denmark 2002; C. Kenwood, A Business Case Study of Open Source Software, MITRE, 2001, http://www.mitre.org/support/papers/tech_papers_01/kenwood_software

³⁸ *Ibid*; *Ibid*

³⁹ *Ibid*; *Ibid*

⁴⁰ J. Dalzell, Open standards versus open source in e-learning, MELCOE, Macquarie University, 2003, p2, <http://www.melcoe.mq.edu.au./documents/E-learning.OSS and OpenStandardsrev1.doc>; M. Fisher, Open source software and the role of Linux in the public sector, IBM, 2003

⁴¹ *Ibid*; *Ibid*

⁴² See World Wide Web Consortium (WC3), <http://www.w3.org/>; IMS Global Learning Consortium Inc., What we do, 2002, <http://www.imsglobal.org/faqs>; Object Management Group (OMG) <http://www.omg.org/>,

⁴³ J. Dalzell, Open standards versus open source in e-learning, MELCOE, Macquarie University, 2003, p2, <http://www.melcoe.mq.edu.au./documents/E-learning.OSS and OPenStandardsrev1.doc>

⁴⁴ M. Fisher, Open source software and the role of Linux in the public sector, IBM, 2003

⁴⁵ J. Dalzell, Open standards versus open source in e-learning, MELCOE, Macquarie University, 2003, p2, <http://www.melcoe.mq.edu.au./documents/E-learning.OSS and OpenStandardsrev1.doc>

⁴⁶ See P. Schimitz & S. Castiaux, Pooling open source software: An IDA Feasibility study – Interchange of data between administrations, European Commission, 2002, <http://europa.eu.int/ISPO/ida/export/files/en/115.pdf>

source software provides a practical method of developing open standards.⁴⁷ Open source software and open standards then fit together like a 'hand in a glove'.⁴⁸

Examples of open standards are the Shareable Content Object Reference Model (SCORM)⁴⁹ and Extensible Markup Language - XML.⁵⁰ SCORM is a set of technical standards that enable web based learning systems to find, import, share, reuse and export content in standardised ways.⁵¹ XML is developed by WC3 and provides a starting point for a standard for general office documents. WC3 is also developing a range of connected standards to define layouts.⁵²

The Common Object Request Broker Architecture (CORBA) is a piece of software that uses a standard protocol to provide open, vendor-independent architecture that allows computer applications to work together over networks.⁵³

The following two diagrams illustrate how open standards underpin other software systems.

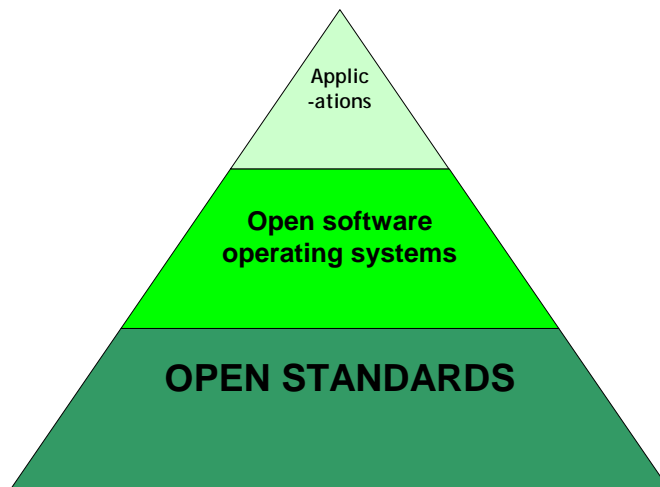


Diagram 2: Open standards underpin open source software

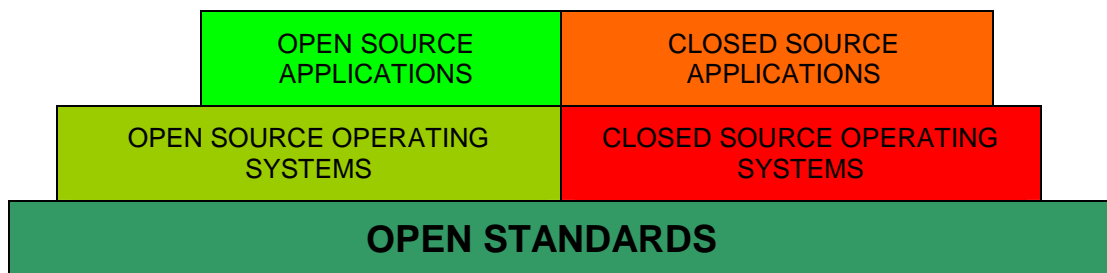


Diagram 3: Open standards underpin open and closed source software

⁴⁷ See C. Kenwood, A Business Case Study of Open Source Software, MITRE, 2001, pxii-xiii, http://www.mitre.org/support/papers/tech_papers_01/kenwood_software

⁴⁸ Board of Technology, Government of Denmark, Open-Source Software in Digital Management in the Public Sector, Government of Denmark 2002, p19; N. Peeling & J. Satchell, Analysis of the impact of open source software, QintetoQ Ltd, 2001

⁴⁹ See Randall House Associates, SCORM, 2003, <http://www.rhassociates.com/scorm.html>

⁵⁰ Board of Technology, Government of Denmark, Open-Source Software in Digital Management in the Public Sector, Government of Denmark 2002, pp24-25

⁵¹ See Randall House Associates, SCORM, 2003, <http://www.rhassociates.com/scorm.html>

⁵² Board of Technology, Government of Denmark, Open-Source Software in Digital Management in the Public Sector, Government of Denmark 2002, pp24-25

⁵³ D. Schmidt, Distributed object computing with CORBA middleware, 2003, <http://www.cs.wustl.edu/~schmidt/corba.html>

An open standards computing system would comprise software, hardware and people interacting, where the computer interface specifications were fully defined, publicly available and maintained according to industry consensus.

DRIVERS

There are several reasons why schools and school systems along with a variety of Australian government agencies are considering using open source software. Reasons vary according to the context and location. Three examples are discussed here: budget challenges; the ability to prototype quickly and cheaply; and for some schools there are pedagogical reasons for using open source software. The reasons discussed here are intended as a report, rather than as a justification: as indicated earlier, a total cost of ownership analysis was beyond the scope of this paper.

Budget challenges

Different IT budget challenges are faced in different contexts. The combined costs of computer hardware, software, telecommunications and increasing demands on electricity are adding costs to the budgets of individual schools and sectors. These budget challenges are pushing some schools and sectors to examine ways in which cost savings can be achieved while still providing students and teachers with access to and use of ICT facilities and services.⁵⁴ Software is one component of the costs where the potential for some savings is being examined. Some schools are also using open source software to extend the life of their computer hardware.⁵⁵

Proprietary software

Discussion by jurisdictions about the cost of proprietary software has been undertaken.⁵⁶ It is estimated that collectively the respective government schooling systems (excluding the Northern Territory) pay Microsoft® in excess of \$33 million per annum in Microsoft® Enterprise Agreement licences.⁵⁷ It is unknown how much is paid nationally for Microsoft® licences by the schools in the non-government sector. Furthermore it is unknown how much the government and non-government schooling sectors pay for other proprietary software such as Adobe products. Schools and sectors now are also considering the cost of purchasing proprietary learning management systems, but these potential costs too are being weighed up carefully.⁵⁸ Different software options including open source software applications are being considered as the costs of software are being questioned.

Computer hardware- software upgrade-computer hardware upgrade cycle

As schools and systems receive new upgrades of proprietary software this brings with it increased demands for computer hardware space and memory to handle the requirements of the software. Software upgrades place some schools into the position of having to purchase new computers.⁵⁹ For example, a school that has around 1500

⁵⁴ This has been reported by individual schools and is noted in J. Kenway, *Reality bytes: education, markets and the information superhighway*, The Australian educational researcher. 22, 1, 1995, pp 35-66.

⁵⁵ The Swedish Agency for Public Management has found that open standards along with open software are important factors in gaining increased competitiveness, improved interoperability and reduced costs for administration in the Swedish public sector. See: Swedish Agency for Public Management, Free and open software, <http://www.statskontoret.se/pdf/200309eng.pdf>

⁵⁶ See MCEETYA ICT in Schools Taskforce papers, 20 March 2003, Agenda item 10

⁵⁷ K. Moyle, *The hegemony of Microsoft®*, Prometheus, Vol.21, No.2, June 2003b, pp213-230

⁵⁸ Some states are testing, piloting and trialing different learning management systems

⁵⁹ The trend of hardware upgrading frequency on a cycle of 3 to 4 years as a result of Microsoft software upgrades was identified and analysed in the Government of Denmark report: See Board of Technology, Government of Denmark, Open-Source Software in Digital Management in the Public Sector, Government of Denmark 2002, p42

enrolments and a computer to student ratio of one computer to five students is likely to have around 300 computers for student use. If this school planned to change over a third of its computers each year over a three year time frame, at a conservative cost of \$1000 per computer, this would represent an annual recurrent cost to the school of over \$100 000 in computer hardware purchases alone.⁶⁰ De facto, this approach to software supply to schools generates its own cycle of hardware demand: when the software requirements on a computer increase, this generates the requirement for the purchase of new computers and so on. This cycle has the potential to lock schools and departments into cycles of purchasing that some are concerned will widen the 'information rich/information poor' divide.

While it is seen as preferable for support services provided to schools to be focused upon a small age range of computers, at the local level open source software solutions are seen by some schools to provide them with the opportunity to get more use out of older hardware.⁶¹ One of the strengths of open source software is its capability to run on older hardware.⁶² This therefore allows these schools to improve their overall computer power by gaining more life out of their hardware.

Technical support and thin client solutions

Obtaining sufficient technical support is a concern for some schools. Schools and sectors, like banks, retail stores and hotel chains⁶³ have computers distributed over different locations. Research in contexts similar to school education indicates that where there are few people to maintain the computers, the reliability of the open source operating system, Linux, especially when used with thin client solutions⁶⁴ may reduce the need for a full-time technician at each site.⁶⁵

Ability to prototype quickly and cheaply

Open source software provides an inexpensive developers platform. National education and training organisations such as **education.au limited** and private companies building websites use open source software as a way of keeping ongoing costs and risks to a minimum while maximising the breadth and sophistication of their service delivery or materials development.⁶⁶

Software scope creep

Schools and sectors introducing new initiatives tend to trial the initiative prior to a full implementation. The use of proprietary software in projects that are to expand to accommodate increasingly larger groups of people however, raise questions for the project about how the emerging licensing regime and the associated budget issues

⁶⁰ This cycle of computer upgrades has been reported in the open source trial conducted in an R-12 school in South Australia; by some non-government schools; and by the Danish Government, see Board of Technology, Government of Denmark, Open-Source Software in Digital Management in the Public Sector, Government of Denmark 2002

⁶¹ This trend is also reported in private enterprise in Gartner research. See M. Hubley & N. Muller, Linux: What major IT vendors are doing, Gartner, 2002, p3 <http://asiapac.gartner.com/events/noie.cfm>

⁶² See Board of Technology, Government of Denmark, Open-Source Software in Digital Management in the Public Sector, Government of Denmark 2002; Open-Source Software in Digital Management in the Public Sector, Government of Denmark 2002, p50; M. Hubley & N. Muller, Linux: What major IT vendors are doing, Gartner, 2002 <http://asiapac.gartner.com/events/noie.cfm>

⁶³ See M. Hubley & N. Muller, Linux: What major IT vendors are doing, Gartner, 2002, p3 <http://asiapac.gartner.com/events/noie.cfm>

⁶⁴ The case study of Moreland School District in the USA provides indicators on this. See <http://www.sun.com/edu>

⁶⁵ For example, it will be seen shortly that technical expertise is provided centrally from Darwin using Linux on mirrored computers.

⁶⁶ See G Putland, J. Leeson, G. Hendrick, Re-engineering the national online Services (EdNA Online) for education and training in Australia, EduCause in Australasia, 2003 pp546-566; similar reasons were identified in an Indian case study reported in Dravis Group, Open source software: Case studies examining its use, The Gravis Group, 2003, [http://www.dravis.net/images/Open%20SourceSoftware%20\(Dravis\).pdf](http://www.dravis.net/images/Open%20SourceSoftware%20(Dravis).pdf)

should be handled.⁶⁷ It adds a layer of complexity to the project management. The use of open source software allows projects to extend and for more users to join a project without having to be concerned about the additional licensing costs. Using open source software is seen by some schools and sectors as providing a mechanism whereby they are able to maintain their focus on the project and the organisational value of the applications rather than the licensing and budget issues associated with the software.

Pedagogy

Apart from the technical and budget reasons why open source software solutions are attractive to some schools and school systems, there are pedagogical reasons why schools may opt to use open source software. The national goal of schooling 1.6 states that all students will leave school as 'confident, creative and productive users of new technologies, including information and communication technologies, and understand the impact of those technologies on society'.⁶⁸ In this context, some teachers see that it is important to teach students to question and problem solve both within and outside the boundaries imposed through the use of closed source code systems. Because the code in open source software is open and viewable, it is a simpler teaching tool for computer programming classes as teachers and students are able to see the code and see what the code does.⁶⁹ Closed source software is not viewable so students learn about this code in the abstract.⁷⁰

Pedagogical reasons have been the motivation for introducing the use of open source software within some non government schools including Sydney Church of England Girls Grammar School in New South Wales;⁷¹ and Strathcona Baptist Girls Grammar School⁷² and Trinity College⁷³, both in Melbourne. In doing so, students in these schools are able to develop an understanding of how to use technologies without assuming that the Microsoft® environment is the only one in which computing can occur. Consistent with the national goal of schooling 1.6, the approaches taken in these schools also facilitates the development of students' understandings about the impact of technologies on society, including the impact of multinationals on software development and use.

Teachers at Strathcona Baptist Girls Grammar School were initially concerned that by teaching students how to use open source software would be seen by parents and the local community as problematic. They were concerned that the view the school was not solely using Microsoft products would disadvantage students in their transition from school to work and further education and training. These concerns have not been realised and the use of open source software at this school is a 'non-issue'.⁷⁴

Teachers at Sydney Church of England Girls Grammar School (SCEGGS) take the pedagogical view that "students don't know a word processor until they know more than

⁶⁷ Similar drivers for avoiding 'scope creep' were reported several US Federal government agencies, outlined in Dravis Group, Open source software: Case studies examining its use, The Gravis Group, 2003, [http://www.dravis.net/images/Open%20SourceSoftware%20\(Dravis\).pdf](http://www.dravis.net/images/Open%20SourceSoftware%20(Dravis).pdf)

⁶⁸ MCEETYA The Adelaide declaration on national goals for schooling in the twenty-first century, Curriculum Corporation 1999, p2, <http://www.curriculum.edu.au/mceetya/nationalgoals>

⁶⁹ This point was reiterated by Randy Adams from North Michigan University, USA at the EducationalLinux 2003, University of Western Australia

⁷⁰ This point was reiterated by James Hamilton from Canberra Institute of Technology at the EducationalLinux 2003 conference, University of Western Australia

⁷¹ Reported by Mr Kim Perkins, Strathcona Baptist Girls Grammar School at the EducationalLinux 2003 conference, University of Western Australia

⁷² See K. Perkins, Open source networks in education – the deployment of a Linux network in the K-12 domain, Australian Computers in Education Conference 2002; P. Lesslie, Open source software in schools – draft, http://homepages.ihug.com.au/~toxnet/oss_in_schools/main.html

⁷³ R. Wraith, Trinity College Victoria, Australian Computers in Education Conference 2002

⁷⁴ Reported by Mr Kim Perkins, Strathcona Baptist Girls Grammar School at the EducationalLinux 2003 conference, University of Western Australia and confirmed for this paper.

one.” Students are deliberately exposed to more than one sort of office applications software to provide depth to their education experiences and to enable the girls to question and problem solve inside and outside of closed source proprietary software systems. Parents are very supportive of this approach.⁷⁵

WHAT GARTNER SAYS

Gartner is a well regarded US based company that undertakes IT related research. The research undertaken by Gartner is mostly US based, however, respective Australian governments and private enterprise tend to refer to its research as an indicator of industry drivers and market trends. This section of the paper provides some indication of Gartner’s recent work concerning open source software.

At a National Office of the Information Economy (NOIE) workshop *Open source software and the role of Linux in the public sector* held early in 2003 for government CIOs, the Research Director at Gartner identified the following statements as open source software myths:

- *open source is against commerce*
- *it's just a passing fad. It's against human nature to work for nothing. Development is done by hackers and students*
- *Nobody controls development. Anybody can change the software, which eventually becomes unstable and insecure*
- *There is no one to turn to for support*
- *When the lead developer leaves, the project dies*
- *Open source projects eventually splinter, just like Unix.*⁷⁶

Gartner is finding technical evidence is emerging that challenges these myths and that demonstrates certain open source software such as the Linux operating system is now reliable and robust. The following extracts pertaining to the technical characteristics of particular open source software have been drawn from recent Gartner research.

In May 2002 Gartner research indicated that:

*By 2006 Linux will be a key foundation for a strategic, cross-development-platform environment, accelerating Unix server consolidation, while creating a powerful alternative to Windows.NET.*⁷⁷

In October 2002 Gartner research made the strategic assumption that

*By 2004, up to 5 percent of Global 2000 organizations, especially leading-edge, 'Type A' organizations with a commitment to internal application development, will have used a 'build-and-open-source' approach as an additional option in their application development strategies (0.6 probability).*⁷⁸

'Type A' organisations are those that are early adopters and developers of technology where there is expected to be a competitive edge. Financial institutions such as banks are examples of 'Type A' organisations where the software required has to be custom built as there are no custom packages available.⁷⁹ The DrKW (the investment arm of Dresdner Bank, Germany) developed its message-based integration system with open

⁷⁵ Information provided for this paper by Mr Ian Ralph, IT Coordinator, SCEGGS

⁷⁶ R. Simpson, Does open-source software have a place in your IT portfolio? Gartner 2003, p5, <http://asiapac.gartner.com/events/noie.cfm>

⁷⁷ See M. Fisher, Open source software and the role of Linux in the public sector, IBM, 2003, p24

⁷⁸ N. Drakos, Opportunities in open source user innovation networks, Gartner, 2002, p1, <http://asiapac.gartner.com/events/noie.cfm>

⁷⁹ *Ibid*

source software and then released it to the community.⁸⁰ This work provides indications of where technical developments for distributed organisations are heading.

In late 2002 Gartner reported that

*Linux has demonstrated its reliability to the point that businesses of all types and sizes have come to regard it as a worthy alternative to proprietary Unix platforms such as HP's HP-UX and IBM's AIX, as well as Microsoft's Windows. ... Linux has amply proven itself in a number of infrastructure environments that go beyond simple file-and print services, such as caching, virtual private network (VPN) networking, DNS and proxy, Web server, and messaging. It is capable of running server clusters, and there are now Linux tools for system management and performance tuning. Linux is capable of running a variety of mainstream business applications such as accounting, databases, and conferencing ...*⁸¹

Also at the aforementioned NOIE 2003 workshop, the Gartner research was presented which compared Linux to Windows 2000. In part it indicated the following:⁸²

2002	Linux	Windows NT
Horizontal scaling	Excellent	Deficient
Security	Acceptable	Deficient
Appliance pricing	Excellent	Acceptable

Further it was reported that

*Linux will generally have better price/performance characteristics against simple Unix/RISC configurations. Linux will generally do better against Windows in larger, replicated server placements.*⁸³

WHAT'S HAPPENING IN AUSTRALIA & NEW ZEALAND?

Australia is lagging behind other OECD countries in considering the implications of open source software in government. The governments in UK, USA, Asia, South Africa, across Latin America and the European Union have commissioned reports or have government policies concerning the potential use of open source software.⁸⁴ No comparable research

⁸⁰ *Ibid*

⁸¹ M. Hubley & N. Muller, Linux: What major IT vendors are doing, Gartner, 2002, p6
<http://asiapac.gartner.com/events/noie.cfm>

⁸² R. Simpson, Does open-source software have a place in your IT portfolio? Gartner 2003
<http://asiapac.gartner.com/events/noie.cfm>

⁸³ R. Simpson, Does open-source software have a place in your IT portfolio? Gartner 2003, p18,
<http://asiapac.gartner.com/events/noie.cfm>

⁸⁴ See Office of Government Commerce, Open source software. Use within UK government version 1. 15 July 2002, <http://www.ogc.gov.uk/index.asp?id=2190>; G. Taylor, Open source software – destroying the myths, OpenForum Europe, pp242-244, <http://www.openforumeurope.org>; MITRE Corporation, Use of free and open-source software (FOSS) in the U.S. Department of Defense, Version 1.2.04 January 2, 2003, <http://www.egovos.org/pdf/dodfoss.pdf>; The Dravis Group, Open source software: Case studies examining its use, The Gravis Group, 2003, [http://www.dravis.net/images/Open%20SourceSoftware%20\(Dravis\).pdf](http://www.dravis.net/images/Open%20SourceSoftware%20(Dravis).pdf) National Advisory Council on Innovation, Open Software Working Group, Open software and open standards in South Africa: a critical issue for addressing the digital divide, 2002 <http://www.naci.org.za/docs/opensource.htm>; D'Empaire, A. *Microsoft's big stick in Peru*, Wired news, 2002, Board of Technology, Government of Denmark, Open-Source Software in Digital Management in the Public Sector, Government of Denmark 2002; Open-Source Software in Digital Management in the Public Sector, Government of Denmark 2002; Swedish Agency for Public Management, Free and open software, <http://www.statskontoret.se/pdf/200309eng.pdf>

work has been undertaken in Australia. Brazil, Peru, Italy and a few states in the USA⁸⁵ are among countries around the world drafting or implementing open source software legislation. The basic underpinning premise of the respective pieces of legislation is to have governments consider open source software solutions equally alongside proprietary software solutions.⁸⁶

A brief scan is provided here of what is happening in Australia in relation to open source software politically; in Federal government departments; and in education and training. This scan should not be taken as indicating the full picture of what is happening in relation to open source software in Australia as a detailed, comprehensive audit has not been taken across state, territory and federal government departments nor across schools. There appears however, to be growing interest in the potential uses open source software offers schools.

Draft legislation

There is political activity around the question of open source software in government. Reportedly, the Federal Australian Labor Party is developing a position paper for consideration at their January 2004 national conference;⁸⁷ and Senator Brian Grieg leader of the Australian Democrats, has announced his intention to introduce a Federal Private Members of Bill⁸⁸.

In South Australia, the Australian Democrats have introduced draft legislation called the State Supply (Procurement Of Software) Amendment Bill 2003. The crux of this draft legislation is the following section (17A):

*A public authority must, in making a decision about the procurement of computer software for its operations, have regard to the principle that, wherever practicable, a public authority should use open source software in preference to proprietary software.*⁸⁹

It is reported that this Bill will be debated by the South Australian Parliament later in 2003.⁹⁰

In the ACT and in New South Wales it is reported that new Bills are being prepared by the Australian Democrats and the respective Parliamentary Councils. It is expected that these Bills will be introduced into the respective ACT and New South Wales Parliaments shortly.⁹¹

Federal government

Federal government policy is supportive of investigating the use of open source software from the point of view of value for money. Some Federal government departments are using open source software or are investigating the potential of it in their agency.

For more details see Appendix Three - What is happening overseas;

⁸⁵ See P. Festa, Governments push open-source software, CNET News, August 29, 2001, <http://news.com.com/2100-1001-272299.html?legacy=cnet>; M. Fisher, Open source software and the role of Linux in the public sector, IBM, 2003; see also Appendix Three

⁸⁶ *Ibid*; *Ibid*

⁸⁷ See J. Riley & K. Mackenzie, *Labor heads to the open source*, AustralianIT, 26 June 2003, <http://australianit.news.com.au>

⁸⁸ A. Colley, *AU Democrats take open-source legislation to Senate*, ZDNet News, 4 July 2003, <http://www.zdnet.com.au/newstech/os/story/0,2000048630,20275940,00.htm>

⁸⁹ Gilfillan, M.L.C. State supply (Procurement of software) amendment Bill 2003, An Act to amend the State Supply Act 1985, South Australia, p3

⁹⁰ S. Haynes & J. Riley, *Open source trade clash*, AustralianIT, July 1 2003, <http://australianIT.news.com.au>

⁹¹ See AustralianIT, *Have your say: open source trade clash*, AustralianIT July 7 2003, <http://australianIT.news.com.au/articles/0,7204,669968^nbv^15309,00.html>; AustralianIT, *Greens battle Microsoft*, AustralianIT July 29 2003, <http://australianit.news.com.au/articles/0,7204,6827248^5E15306^5E%5E%5Enbv^5E,00.html>

'Better Services, Better Government'

At the federal 'whole of government level' NOIE has released the policy strategy *Better Services, Better Government* (2002) which states that:

The Government will encourage trials of open source software within the framework of fit for purpose and value for money" (p21); and the Re-use of [IT] assets will be enhanced by greater commonality of architecture and open standards" (p20)⁹²

The NOIE portal includes an open source software page with information and resources available from it.⁹³

Backing Australia's Ability: National ICT Centre of Excellence

The National ICT Centre of Excellence (National ICT Australia (NICTA)) is a \$129 million initiative funded through the federal government's innovation plan *Backing Australia's Ability*.⁹⁴ NICTA is a limited liability company whose shareholders are the four founding partners:

- The Australian National University
- The University of New South Wales
- The New South Wales Government
- The Australian Capital Territory Government.⁹⁵

A joint venture between the NICTA and IBM Australia is establishing the Centre for Advanced Studies (CAS) to consolidate the \$40 million IBM invests in Australian national research each year.⁹⁶ The first new project under this initiative is a collaboration on open source software. This is a three year collaborative project, being undertaken by National ICT Australia (NICTA) at its University of New South Wales site. The initial phase of the project will involve seconded staff, as well as PhD and Honours students from the University. The research is to focus on increasing the technical performance of open source software like Linux.⁹⁷

Centrelink⁹⁸

Centrelink is the federal government's biggest service delivery agency and relies on its substantial information technology capability to deliver core services and payments. Centrelink's approach to open source is assessed on a case by case basis that must deliver benefits to the agency in both efficiency and effectiveness. It already utilises open source code in certain parts of its infrastructure services. In 2002 Centrelink signed a four-year contract with IBM to provide mainframe capacity and associated software and services. Additional benefits of the enterprise licensing agreement included the ability for Centrelink to jointly construct with IBM a Linus Laboratory for the purpose of software trials, validation and benchmarking of functionality. Centrelink has drafted its Linux Strategy and is anticipating opportunities to test Linux as a suitable enterprise platform over the coming months.

⁹² National Office for the Information Economy (NOIE) *Better services, better government*, Commonwealth of Australia, Canberra, 2002

⁹³ See National Office of the Information Economy (NOIE) *Open source software* <http://www.noie.gov.au/projects/egovernment/better%5Finfrastructure/oss/index.htm>

⁹⁴ National ICT Australia Ltd, *Overview*, 2003, http://nicta.com.au/nicta_home.html

⁹⁵ *Ibid*

⁹⁶ See R. Alston, *Media Release: New NICTA/IBM joint venture kicks off improved industry/research links*, 30 April 2003, http://www.dcita.gov.au/Article/0,,0_4-2_4009-4_114124,00.html; National ICT Australia Ltd., *Media Release, Boost for Australian research community and enterprise community IBM and NICTA collaborate on open source*, 30 April 2003, <http://nicta.com.au/>

⁹⁷ National ICT Australia Ltd., *Media Release, Boost for Australian research community and enterprise community IBM and NICTA collaborate on open source*, 30 April 2003 <http://nicta.com.au/>

⁹⁸ This information was provided by Centrelink specifically for this paper

Commonwealth Bureau of Meteorology⁹⁹

Open source software is used at the Bureau of Meteorology for the digital library services they use for the physical sciences, for the Forecaster desktop and for the Internet. The open source software VisAD is used for the digital physical sciences library. This open source software was developed at the University of Wisconsin. It is object-oriented and extendable. It is written with Java portability; is intended for distributed use and supports a wide range of file formats including GIF, JPEG and EOS.

The Bureau of Meteorology has a complex IT infrastructure. It has:

- 2 NEC SX 5 supercomputers (32 processors, 192 Gbytes RAM, terabytes of disc)
- IBM SP2 (12 processor)
- 70 midrange Unix servers
- 200 workstations and 1700 PCs
- 120+ terabytes of online storage

Some of the reasons why the Bureau of Meteorology is using open source software include the following:

- IT permeates the culture of the organisation
- the Bureau of Meteorology has a long history of public service and the open source public good model matches well with the practice of the Bureau – that of providing free and open weather services and data
- the market for weather services software is small and primarily non-commercial
- the culture of the workforce at the Bureau of Meteorology is that of a learning organisation, with the workforce highly educated and motivated. The Bureau has a strong research base and the open source model fits well with their research models.

Department of Veteran's Affairs¹⁰⁰

The Department of Veteran's Affairs took the opportunity when it came time to renegotiate their outsourced IT arrangements to consider the use of open source software as well as proprietary software. The drivers for this included:

- Meeting the corporate strategy
- Improving the methods of business delivery
- Refreshing the IT infrastructure
- Consolidating file/print, mail and database servers
- Satisfying the required value for money criteria.

As a result, the Department of Veteran's Affairs is using a Linux mainframe to replace some servers. They have found that the technical solution is feasible and based on the Department's risk assessments has a high probability of success.

Education and training

Open source software is an emerging issue for all education and training sectors across Australia. This section of the paper provides some insights into this work but should not be considered as comprehensive. As indicated earlier, no formal research or review of open source software use in schools has been undertaken in Australia.

education.au limited

The Ministerial company ***education.au limited*** develops and maintains the education and training portal EdNA Online which is a gateway to online resources for the schools, training and higher education sectors. Collaboration is at the centre of the organisation's

⁹⁹ P. Gigliotti, Use of open source software in the Bureau of Meteorology, Notes from presentation at National Office of the Information Economy Workshop, 18 February 2002

¹⁰⁰ A. Ablong, DVA's journey with Linux, Notes from presentation at National Office of the Information Economy Workshop, 18 February 2002

activities. The open source model matches the philosophy of *education.au limited's* role and its' work.

EdNA Online has been undergoing a refurbishment. The architecture of the new EdNA Online Portal is shown below in Diagram 4. The portal has been implemented using software that adheres to J2EE standards. Open source software and software that is referred to as 'collaborative' rather than strictly open source have been used. Jahia is an example of 'collaborative' software. The Jahia software model makes the software freely available on the basis that the user contributes back into the development community. If the user does not contribute back into the development community then they are charged a small fee for the software. *education.au limited* has found that open source software has the capacity to provide enterprise level web portal systems that are robust and reliable, and are a viable alternative to proprietary products.¹⁰¹

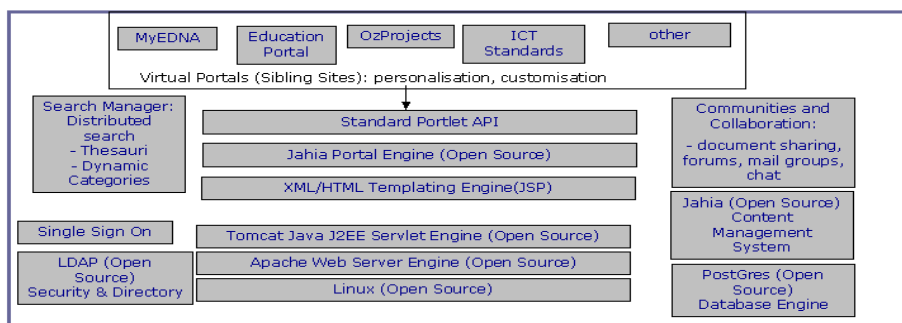


Diagram 4: EdNA Portal Architecture¹⁰²

School sector

The following summary of the use of open source software in the Australian school sector is a result of several processes:

- conversations and email communications with officers within each of the jurisdictions and in Ministerial companies;
- a scan the Internet for Australian schools documenting their use of open source software; and
- participating on an Australian open source/school education listserv.

Some states and territories have indicated that open source software is being used in individual schools and in sectors for a range of purposes including:

- as the back end to curriculum servers;
- as the back end to administration servers;
- at the front and back of computers;
- networking; and
- in computer laboratories.

¹⁰¹ G Putland, J. Leeson, G. Hendrick, Re-engineering the national online Services (EdNA Online) for education and training in Australia, EduCause in Australasia, 2003, pp546-566

¹⁰² *Ibid*, p559

Several jurisdictions indicated in the conversations concerning open source software that they would be interested in establishing national mechanisms for learning more about the software's potential.

In addition to **education.au limited**, the national initiative The Le@rning Federation has been engaging with open source software.

The Le@rning Federation

In July 2001 MCEETYA agreed to The Le@rning Federation (TLF) initiative. To access the learning objects requires the use of the Basic E-Learning ToolSet (BELTS). BELTS is an open source learning management system developed by TLF. This development will conclude in early 2004. Research is required for states and territories to determine BELTS' longer term applicability and viability; any additional functionality required and identification of the required documentation.

Curriculum Corporation

The Curriculum Corporation have a number of open source software tools to support their project and corporate activities:

- Apache & TomCat Web Servers
- Mysql and Posgresql Data bases
- Mailman List Serve

The Curriculum Corporation are maintaining a watching brief on developments in open source software. Curriculum Corporation does not see itself as an early adopter of new technologies, and wants to see a critical mass of institutional and organisational users before they move to use any further open source software for product development.

Australian Capital Territory

The Department of Education, Youth and Family Affairs in the ACT is interested in open source software but cautious about its use. Every school has been provided with an open source proxy server firewall. A number of schools are using Linux based services on their student networks. The Department does not discourage the use of open source software on school student networks and provides a model Linux environment that schools are free to adopt and adapt. Schools are obliged to use Windows on their administration systems.

Northern Territory

In July 2001, following a tender process, the IT company CSM Technology was engaged to assist the Northern Territory Government's Department of Employment, Education and Training (DEET) to provide a range of services which included the supply, installation and commissioning of 3,715 desktops and 192 servers into 192 schools across the Northern Territory; and to supply, install and manage the department's central Internet portal infrastructure to facilitate communications with the school servers.¹⁰³

CSM believe their tender bid was successful because it represented the best value for money, as their proposal to undertake this work was based upon using Linux on the servers. Their proposal has now been successfully implemented. The deployment of the school servers occurred using a centralised model of deployment where each server was mirrored and installed in schools. These servers are updated and maintained centrally by CSM from Darwin. This approach has been adopted in part to overcome the lack of technical expertise located in the various remote schools in the Northern

¹⁰³ CSM Media Release, \$10 million IT business for Territory, 2002, http://www.csm.com.au/tech/attachments/csm-sra_media_release_final.pdf

Territory; to provide a robust and reliable system; and to overcome difficulties in physically accessing some schools during parts of the year, due to the weather.¹⁰⁴

New South Wales

Department of Education and Training

The Department of Education and Training has statewide enterprise agreements in place that permit the use of a range of Microsoft and Novell products in schools, including network operating systems. However, departmental policy has not restricted the use of open source software in schools.

Based on local needs and expertise, schools have made independent decisions regarding the servers, operating systems and other software they use. As many as 1,000 schools have implemented some form of open source system, such as Linux file, print, web, proxy or caching servers. In addition, as part of the Department's Technical Support in Schools project, 100 proxy caching servers, using the FreeBSD operating system, have been deployed in pilot schools.

The Department has installed the Le@rning Federation's Basic E-Learning ToolSet (BELTS) at its St Leonards computer centre. A limited trial is currently being planned to fully determine the capabilities of BELTS. However, the Department already understands that BELTS is not capable of supporting statewide deployment to all NSW schools.

Corporate systems development in the open source arena has commenced. A Linux-based product is being used to construct the Department's new Enterprise Portal. The portal will provide users with a secure, standard browser interface and a single controlled point of entry to services when using the Department's network. This is the first development in what is expected to be a growth area for corporate applications development architectures.

Some additional applications development utilising open source systems and applications has occurred in a number of locations within the Department. The support implications of this work are yet to be fully ascertained and the Department is currently working towards the establishment of department-wide applications development standards. Any systems development using open source products that has already taken place will be accommodated within the standards environment that is put in place.

Office of Best Practice IT and Corporate Services

The NSW Government through its Office of Best Practice IT and Corporate Services is currently engaged in an open source project involving 40 state government agencies. The project aims to create a centralised resource to assist in the adoption of open source software in the public sector. It is the Government's view that without a central resource, the NSW public sector may not be able to take advantage of open source software because of a shortage of expertise in individual agencies. Both the Department of Education and Training and the NSW Board of Studies are participating in the whole of government open source project.

New South Wales Board of Studies

The NSW Board of Studies is experiencing cost savings from using open source software and expects to continue to gain significant cost savings from its use. An example where open source software is used at the Board of Studies is in the web-server cluster.

¹⁰⁴ *ibid*

The Board of Studies website was established in 1995 on Linux, and they have been adding sites and servers ever since. The NSW Board of Studies website has the fifth largest traffic of all Government websites (www.hitwise.com.au) and the Board of Studies delivers the HSC results from those servers to 65,000 students with 12,000 of them in the first half-hour on 19 December. The system has proved itself to be rugged and capable.

There are savings on other products like the open source mysql versus SQL software. Each version of an SQL upgrade requires additional licences and brings additional costs. Even with one virtual server there are cost-savings as the initial setup is quicker (therefore less expensive) on a Linux server. When this is multiplied over the 50 or so virtual servers at the NSW Board of Studies the cost savings for the agency are significant. With open source software, the agency can build a new server almost at the 'drop of a hat', but with a proprietary product they have to wait for the delivery and purchase of the licenced software product. Even if everything else were equal, just this delay alone adds costs.

The NSW Board of Studies does not pay for source code, software, upgrades or licence renewals. This makes the software and the infrastructure of the agency much more scaleable as there are no budget restrictions on putting as many copies of the software, when and where they want.

The NSW Board of Studies could not afford the initial software costs to develop and/or test applications for some proprietary products. Just the raw software costs were prohibitive without including the ancillary products like virus and security software. They have found that the costs of virus and security software are much greater for Windows and other proprietary products than for open source software products. Access to the code is one of the greatest benefits; the NSW Board of Studies can easily customise the software and cost-effectively automate it to suit their specific needs. Security is dramatically increased at the NSW Board of Studies using open source software because officers can look at the code themselves to discover/verify any holes and rectify them rapidly.

The initial search engine the Board of Studies developed for its website in 1996, was installed and tested for only \$300 because the hard work had been done on a previous open source project. The NSW Board of Studies only had to undertake the portability processes and some tweaking. Portability of open source software solutions means that regardless of when or where the software was developed it is far more likely to be portable than if it was developed on a proprietary system.

The NSW Board of Studies has found the stability with Linux is amazing. The Linux boxes have had about 99.7% uptime since their implementation and that includes facility moves and other 'forced' downtime. Stability of software providers has been seen an issue too, with proprietary software providers disappearing in the 'tech bubble' fall out. It was seen as too high a risk for the NSW Board of Studies to make an investment in proprietary software when the vendor could disappear leaving no-one to be able access, let alone support their code.

Support is provided by in-house staff or by sub-contracted staff, rather than having to wait for a vendor-patch or to log a request with a central software provider. This provides the NSW Board of Studies with significant time savings and therefore cost benefits. Even when outside help is needed to solve software issues, there is an unquantifiable benefit of having people working on the code in a collaborative mindset. As soon as anything is discovered the user groups set about solving the problem, rather than waiting for the problem to be solved in a commercially-viable way, which takes a lot longer period of time and costs more both to the problem solvers and the end users.

At the NSW Board of Studies they see this as why most software innovations start from the open-source community: it is a quick and easy way to get a new product to 'market'. Best practices are not seen as having to be closely-guarded to maintain the competitive edge; they are shared and encouraged, so that the quality of new developments provides an ever-improving cycle of development.

Open source backup software and database solutions are available as part of the primary platform and do not require separately-purchased products or third-party solutions providers. Commercial support is available from commercial vendors who work with open source products. The Board of Studies has found that this support is usually provided at lower costs to that of proprietary software support.¹⁰⁵

Queensland

Education Queensland is not currently investigating open source software. It is proposed however to monitor and assess developments in this area prior to 2005.

Education Queensland's primary concerns about open source software are the cost of maintenance, the shift in Total Cost of Ownership, how best to leverage any use of open source software, the maturity of open source software for enterprise solutions, the availability of skills and the viability of possible suppliers.

There has been however, a re-structure in Queensland to structure common IT services into a whole of government IT Information Architecture. The first targets are to enable common administration applications across several government departments. Education Queensland is implementing some of the international open standards for education IT architecture including LDAP active directory and SOAP (Web Services) software registered with LDAP. Education Queensland is hoping that various vendors will adopt the educational standards and that this will allow open source software use in the future.

South Australia

Four initiatives within the Department of Education and Children's Services (DECS) are being undertaken in South Australia in 2003:

- a joint project between DECS, The Heights R-12 school and the Department of Administrative and Information Services has been undertaken to examine the potential for using open source software in a school environment;
- the Basic E-Learning ToolSet is being trialed in a few schools; and
- an evaluation of open source learning management systems; and
- school-based trials of open source learning management systems.

Open source learning management systems reviewed in South Australia include Moodle, Atutor, Claroline, Zope, Plone, Manhattan, Chef, H2O, and Segue. Moodle and possibly Atutor will be trialed in some schools during Term 3 2003.

There are some government schools in South Australia using Linux and other open source software to run their curriculum servers. Technology School of the Future is providing professional development for teachers using open source software such as Audacity, which is an open source audio recording software package.

Discussions are underway with the Senior Secondary Board of South Australia (SSABSA) concerning the wording of the senior secondary IT curriculum statements, which oblige students to learn computing using only proprietary software.

¹⁰⁵ Information provided by the NSW Board of Studies specifically for this paper

Tasmania

Open source software is used in Tasmania as is appropriate. There is no departmental policy that gives priority to open source software over other software. Some small software tools in use in the department use open source software such as the software used to monitor bandwidth. None of the big mission critical systems use open source software.

Victoria

The Victorian Department of Education and Training (DET) has no current projects involving open source software. BELTS is the first open source software system they will implement. BELTS is being installed centrally and DET is treating it as a proof of concept at this stage. DET expect to install BELTS on a small number of schools' servers as well for an eLearning pilot involving Learning Federation content. DET hope to assess the issues and costs associated with supporting BELTS as well as other software packages used in the pilots.

DET are most interested in the national collaborative trials of open source portal and eLearning software by **education.au limited** and the Le@rning Federation as they provide an opportunity to share the cost and risk of trialling new software and support models.

A marketing, advocacy and focus group called OSV has been established in Victoria. Its' aim is to raise the profile of open source software in Victoria. Its members are Victorian-based companies and developers who see it as an important concept that businesses and governments use open formats and open source software.¹⁰⁶ OSV has joined with DET to run a competition called *Wide Open Code*, for Victorian high school students who are undertaking their VCE. The competition began on 14 July 2003 and concludes on November 7 2003.¹⁰⁷

Multimedia Victoria has launched an open source development program which is at the initial scoping stage.¹⁰⁸

Western Australia

Open Source initiatives in the Department of Education and Training in Western Australia include the following:

- Open source products were evaluated and prototypes were developed over the past 12 months to determine the viability of this approach to software development.
- Over this time the use of product, tools and support communities have been used to develop a number of small to medium sized applications.
- The overall experience has been extremely positive.
- Software has been extremely stable.
- Community support has been very responsive and helpful
- The Department did make a decision to be very deliberate about the products it chose. It examined a number and researched usage and maturity before deploying to a production environment.
- Areas that open source solutions have been examined and used are:
 - Development environment – Tomcat Servlet Container, Jboss Application Server, Struts MVC Framework, CVS Configuration Management
 - Portal – Jahia, JetSpeed, OpenCMS
 - Reporting – Jasper

¹⁰⁶ Open Source Victoria (OSV), Welcome, 2003, <http://www.osv.org.au>

¹⁰⁷ Open Source Victoria (OSV), Wide Open Code, 2003, <http://www.osv.org.au/index.cgi?tid=61>

¹⁰⁸ J. Riley, States open source punt, AustralianIT, March 11 2003, <http://australianIT.news.com.au/articles/0,7204,6106798^nbv^,00.html>

- Content Management – Open CMS
- Web Server – Apache
- Collaboration Suites – PHP Project
- A number of Schools across the system currently use Linux for web servers, proxy and mail gateways.
- The Department is looking to evaluate how Linux might be used within mainstream school environments.
- The ICT and Curriculum directorates of the Department have evaluated StarOffice, and OpenOffice, Office productivity tools with a view to examining how these products might be appropriately integrated into the school system.

Conclusions from this work found by the Department of Education and Training in Western Australia include:

- The use of open source software within the Department has been very positive
- Tools, if selected carefully, are extremely robust.
- Free licensing costs are a major driver for enabling prototyping with minimal costs.
- Requires in-house, high level, expertise to achieve results.
- Requires upfront work to integrate products to achieve a complete solution.
- Is based on Open Standards and can therefore be integrated effectively.
- Communities are very supportive and responsive.
- There are solutions for every conceivable application.
- There is a huge ground swell of interest and as such, skilled resources are easy to find and procure.
- Open Source is not backed by a multi national organisation that is the point of reference if issues arise.

The Department of Education and Training in Western Australia is also conducting trials of the Basic E-Learning ToolSet (BELTS).

New Zealand

There is no official policy around the use of open source software in New Zealand. The Ministry of Education in New Zealand has signed a contract with Microsoft but this agreement does not include server software. Many schools are moving towards Linux as a server solution particularly for smaller rural schools as a single low specification machine provides all the print, file, web, mail serving capabilities that they need with no or minimal maintenance required from the school. There are a number of small vendors promoting the Linux option for servers however one company has created a total solution for schools (firewall, filtering, mail) and is marketing almost exclusively to schools,¹⁰⁹

The New Zealand Ministry is interested in the idea of translating the KDE desktop GUI into Maori.¹¹⁰ MS Windows is not available in New Zealand's indigenous language and a Maori desktop would be popular in New Zealand's Maori language schools.

The New Zealand Ministry of Education is also currently looking at open source Learning Management Systems for the possibility of a nation-wide infrastructure. The Ministry of Education's bilingual teacher portal (www.tki.org.nz) is written using the open source software PHP.

A couple of high schools are trialling Linux desktops through implementations of the Linux Terminal Server project.

¹⁰⁹ See <http://www.smartcom.co.nz/>

¹¹⁰ See <http://i18n.kde.org/teams>

The New Zealand Ministry of Education is also conducting trials of the Basic E-Learning ToolSet (BELTS) and is considering offering Red Hat certification (alongside Cisco and Microsoft) as part of its “Digital Opportunities” program in selected high schools.

Allenton School is an example of an average New Zealand school using a Linux operating system:

- Allenton is a primary school in Ashburton, New Zealand.
- The student enrolment is 330-400 and increasing
- Annual ICT budget: \$18,000 (including \$4,500 from Telecom ‘School Connection’ program). IT budget is six per cent of the school budget (excluding salaries).
- Allenton has 42 computers. Most linked in Linux network: 15 networked in classrooms (one per room); six in a library 'mini-suite'; two in Special Needs room; and the balance for library, administration and teachers' use.
- Standalone machines include seven Macs in junior classes and several Windows PCs elsewhere. The Principal has laptop. There are also ten 'Studentwriter' 'laptop' wordprocessors.
- Networked PCs are Pentiums 133MHz or faster. 23 are CANZ PCs from The Ark in Auckland. A few faster Celerons.
- Mita digital copier which doubles as a network printer¹¹¹

Non-government schools

Several non-government schools are using open source software. Different schools use it in different ways. The following three examples are illustrative of the sort of work non government schools are undertaking:

Sydney Church of England Girls Grammar School (SCEGGS) (NSW) uses open source software for firewalls, email, to support the back end IT infrastructure including the school's website, and uses some open source applications software including an open source content management application for teaching and learning purposes.

The following software and processes are employed:

- SCEGGS uses Linux for their operating systems on four servers. Three servers belong to the school and the fourth is leased from the school's Internet Service Provider (ISP).
- As the school buys new computers they are loaded with the open source applications software, Star Office
- SAMBA is used to enable proprietary software to be run on the Linux servers. eg Distribution of videos for classroom use is handled using Linux as the operating system with MPEG files held on hard disks within each school building. SAMBA is used to allow Windows computers to access the mpg files on the Linux server.
- Apache is the web server used for the school's website
- Authentication and logon by students and parents into the school's site is handled using open source software.
- The open source content management system AUC is used as a teaching and learning tool by teachers to enhance their courses and house materials online for courses. The materials are housed on the school's intranet. Each course has a place for documents and files; a place for Internet links; a calendar; discussion forums; and the courses can be managed by one or more teachers. Students and teachers can access the courses within the school and parents, teachers and students can access the courses from home. The school community see this functionality as highly valuable as AUC allows parents and their daughters to login to their courses to see what work has been completed, what work is to be completed and the timelines for when work is due. Students can submit documents to their teacher using AUC.

¹¹¹ See http://www.tki.org.nz/r/ict/pedagogy/learningpower/case_lo_e.php

- The open source software SquirrelMail is used for email by students
- The SCEGGS Professional Alumni Network (see <http://www.sceggs.nsw.edu.au>) uses Linux as the operating system, PHP, and the open source database mysql
- Students interested in IT have set up their own Linux server and these students are learning to be open source network administrators
- The school is undertaking a thin client trial with Linux Terminal Server Project (LTSP).

SCEGGS has found the use of open source software to provide enormous stability for the IT infrastructure of the school. They have found access to support not to be problematic. SCEGGS uses support provided over the Internet by user groups and occasionally purchases open source software expertise from a commercial operator.¹¹²

Trinity College – University of Melbourne (VIC) indicates on its website¹¹³ that open source software is central to the school's educational objectives. Trinity College indicates that open source software has given them the freedom and the flexibility to emphasize the teaching of basic principles rather than training on particular software packages. It has allowed them to customize their curriculum for the best educational outcome for their students rather than being constrained by closed source packages. In this way, Trinity College indicates it has control over the education it provides, and future innovations it undertakes.¹¹⁴

Strathcona Baptist Girls Grammar School (VIC)¹¹⁵ is using open source software at the front and backend of their IT infrastructure of the school because they were concerned that they were only giving their students access to and experience in one platform (ie the Microsoft platform). About 55% of Strathcona's students enrol in university courses that have an IT component and so they were keen to expand their students' horizons and to prepare them well for university entrance. In addition, for this private school the financial costs of proprietary software were becoming prohibitive.¹¹⁶

Vocational education and training

The Faculty of Business and Information Technology at Canberra Institute of Technology (CIT) currently is conducting a trial of an Open Source Learning Management System (LMS). Other vocational and training providers around Australia are also investigating the potential of using open source learning management systems.

At CIT it is intended that the project will involve developing some open source code to enable the demonstrated system to meet the needs of the Faculty. There are many open source LMS available, including Caroline, Ganessa, Ilias, Moodle, The Manhattan Virtual Classroom, CHEF, LON-CAPA and fle3. Evaluations of these open source LMS will be specifically evaluated against CIT's requirements.¹¹⁷

Granville TAFE in South Western Sydney has been running Linux courses for a number of years. The course includes 'Introduction to Linux'; 'LPI Linux certification study group'; and Linux scripting and programming.¹¹⁸

¹¹² Information provided for this paper by Mr Ian Ralph IT Coordinator at SCEGGS

¹¹³ See Trinity College-University of Melbourne <http://www.trinity.unimelb.edu.au/>

¹¹⁴ *Ibid*

¹¹⁵ See <http://www.strathcona.vic.edu.au/> <http://www.irysec.vic.edu.au/edulink/manual/source/aup/strath.htm>

¹¹⁶ Reported by Mr Kim Perkins, Strathcona Baptist Girls Grammar School at the EducationalLinux 2003 conference, University of Western Australia

¹¹⁷ P. LeCornu, Project proposal, Canberra Institute of Technology 2003

¹¹⁸ See P. Lesslie, Open source software in schools – draft, http://homepages.ihug.com.au/~toxnet/oss_in_schools/main.html

The AShareNet initiative is interested in open source software applications for the VET sector.¹¹⁹

Higher education

Like the school and vocational education and training sectors, work using and investigating the use of open source software in the higher education sector is piecemeal. Several universities around Australia are using open source software for a variety of purposes and are teaching their IT students how to create and use it.

The University of Sydney has computer laboratories that alternate between open source and Windows® operating systems.¹²⁰ Queensland's university-based advanced computing consortium the Queensland Parallel Supercomputing Foundation has installed two Linux SGI machines.¹²¹ The Queensland Parallel Supercomputing Foundation comprises James Cook, Griffith, Queensland Universities and the Queensland University of Technology. Deakin, Monash and the University of Melbourne are all looking to use open source software within aspects of their work.¹²²

Overseas

Around the world, there are examples within both the private sector and governments where there are moves toward using open source software. An overview of what is happening overseas is outlined in Appendix Three.

COSTS, BENEFITS, LIMITATIONS AND MANAGING RISKS

The use of open source software across Australian schools and sectors tends to be idiosyncratic and piecemeal rather than coordinated. The costs and benefits of open source software for Australian schools have not been subjected to research. Costs and benefits of open source software however have been researched in other countries in relation to government and private enterprise. As such, here the reported costs and benefits are drawn from overseas reports¹²³ rather than from Australian research.

Determining costs and limitations

In considering the provision of an IT infrastructure there are direct and indirect costs. Direct costs include the cost of software and hardware, telecommunications, operations

¹¹⁹ Discussion with Ms Carol Fripp, Director of AShareNet at EduCause 2003

¹²⁰ See University of Sydney, School of Information Technologies, School Facilities, 2003, http://www.cs.usyd.edu.au/current_ugrad?handbook2003/facilities.html

¹²¹ J. Riley, Universities' \$8 million Linux foray, AustralianIT, 14 January 2003, <http://australianIT.news.com.au>

¹²² Discussions with Head, Information technology Services Division, Deakin University; Manager, Flexible Learning and Teaching Program, Monash University, Head, Courseware Development, University of Melbourne at EduCause 2003

¹²³ See Office of Government Commerce, Open source software. Use within UK government version 1. 15 July 2002, <http://www.ogc.gov.uk/index.asp?id=2190>; G. Taylor, Open source software – destroying the myths, OpenForum Europe, pp242-244, <http://www.openforumeurope.org>; MITRE Corporation, Use of free and open-source software (FOSS) in the U.S. Department of Defense, Version 1.2.04 January 2, 2003, <http://www.egovos.org/pdf/dodfoss.pdf>; The Dravis Group, Open source software: Case studies examining its use, The Gravis Group, 2003, [http://www.dravis.net/images/Open%20SourceSoftware%20\(Dravis\).pdf](http://www.dravis.net/images/Open%20SourceSoftware%20(Dravis).pdf) National Advisory Council on Innovation, Open Software Working Group, Open software and open standards in South Africa: a critical issue for addressing the digital divide, 2002 <http://www.naci.org.za/docs/opensource.htm>; D'Empaire, A. *Microsoft's big stick in Peru*, Wired news, 2002, <http://www.wired.com/news/business/0,1367,54141,00.html>; Board of Technology, Government of Denmark, Open-Source Software in Digital Management in the Public Sector, Government of Denmark 2002; Swedish Agency for Public Management, Free and open software, <http://www.statskontoret.se/pdf/200309eng.pdf>

and administration.¹²⁴ Indirect costs include downtime, user satisfaction, support costs and the level or reliability the software demonstrates.¹²⁵ While some of the costs can be quantitatively determined, many require qualitative rather than quantitative analysis. An environment that strikes a balance between the costs and benefits is required for a smooth functioning IT environment.

The direct quantitative costs of open source are lower than that of proprietary software.¹²⁶ There is debate however, about the qualitative comparative aspects of the indirect costs of open source software when applied within a school environment.¹²⁷ No Australian school education research exists that addresses the indirect costs of open source software as they apply to a school environment. In order to gain some common points from which to conduct discussions, research work on this matter would be make a useful contribution to the debate.

Management of risks

There are risks in leading and managing an organisation's software requirements, irrespective of whether the software is open or closed. The more decentralised an education sector is however, the less controls there are on software costs and the more diverse the local environments are likely to be.¹²⁸ One of the most contentious issues in distributed organisations is deciding which IT issues are reserved exclusively for central office and those that can be decided at the local level.¹²⁹ Generally, the more freedom is given at the local level for the purchase of software the more expensive the total proprietary software costs are likely to be for the organisation; and the higher the risks individual sites have to manage in order not to compromise licencing arrangements.¹³⁰ The nature of the resolution concerning the degree of autonomy provided to the local level for software provision will affect the degree of risk a school and/or a system is to experience.¹³¹

The management of software is emerging as an important part of the work of schools and sectors from IT, legal, curriculum and administrative perspectives. Schools and sectors requirements of software include the following:

- it is financially sustainable
- it is not overly time consuming to manage
- it ensures security and privacy
- it improves collaboration within and across agencies
- it has short development times
- it is able to accommodate uncertain futures
- it enables the ability to manage costs and reduce risks over time.¹³²

¹²⁴ See C. Kenwood, A Business Case Study of Open Source Software, MITRE, 2001, pxvi, http://www.mitre.org/support/papers/tech_papers_01/kenwood_software; Gartner, distributed computing trends, August 2002, pp4-7

¹²⁵ *Ibid; Ibid*

¹²⁶ . See: Swedish Agency for Public Management, Free and open software, <http://www.statskontoret.se/pdf/200309eng.pdf>

¹²⁷ See Open Options, Total cost of ownership, 2003, http://www.netc.org/openoptions/pros_cons/tco.html

¹²⁸ Consortium for School Networking, Taking TCO to the classroom, 2001; Board of Technology, Government of Denmark, Open-Source Software in Digital Management in the Public Sector, Government of Denmark 2002

¹²⁹ See Board of Technology, Government of Denmark, Open-Source Software in Digital Management in the Public Sector, Government of Denmark 2002; L. Murphy, Curriculum software: Business Case, DECS (SA) 2003

¹³⁰ *Ibid, Ibid*

¹³¹ *Ibid, Ibid*

¹³² See Board of Technology, Government of Denmark; Board of Technology, Government of Denmark, Open-Source Software in Digital Management in the Public Sector, Government of Denmark 2002; Open-Source Software in Digital Management in the Public Sector, Government of Denmark 2002; Swedish Agency for Public Management, Free and open software, <http://www.statskontoret.se/pdf/200309eng.pdf>; C. Kenwood, A Business Case Study of Open Source Software, MITRE, 2001, http://www.mitre.org/support/papers/tech_papers_01/kenwood_software

Risks for schools and sectors with proprietary software include the following:

- administrative costs of software licence compliance and maintenance of records
- adding and deleting software to machines consistent with licence agreements
- lack of professional development for staff concerning the regulations associated with software compliance and non compliance
- the provision of appropriate technical support
- compliance with the Trade Practices Act.¹³³

Strengths of open source software include:

- Open licenses and control over the intellectual property
- Minimising project start up costs
- Minimising supplier licence management
- Supporting skill transfer through technical support across the organisation
- Peer support groups are available on the Internet for free
- Vendor support is available for a price
- It avoids lock-in and enables flexibility
- Collaboration and learning organisations are supported in philosophy and practice
- It allows cheap prototyping
- It develops the local industry
- It increases software reuse across the organisation at lower cost which sees a greater return on investment.¹³⁴

Costs of open source software include:

- Training costs and other internal support costs
- Determining which software to use
- External support costs.¹³⁵

The following diagram provides an overview of some of the costs and benefits of open source software.

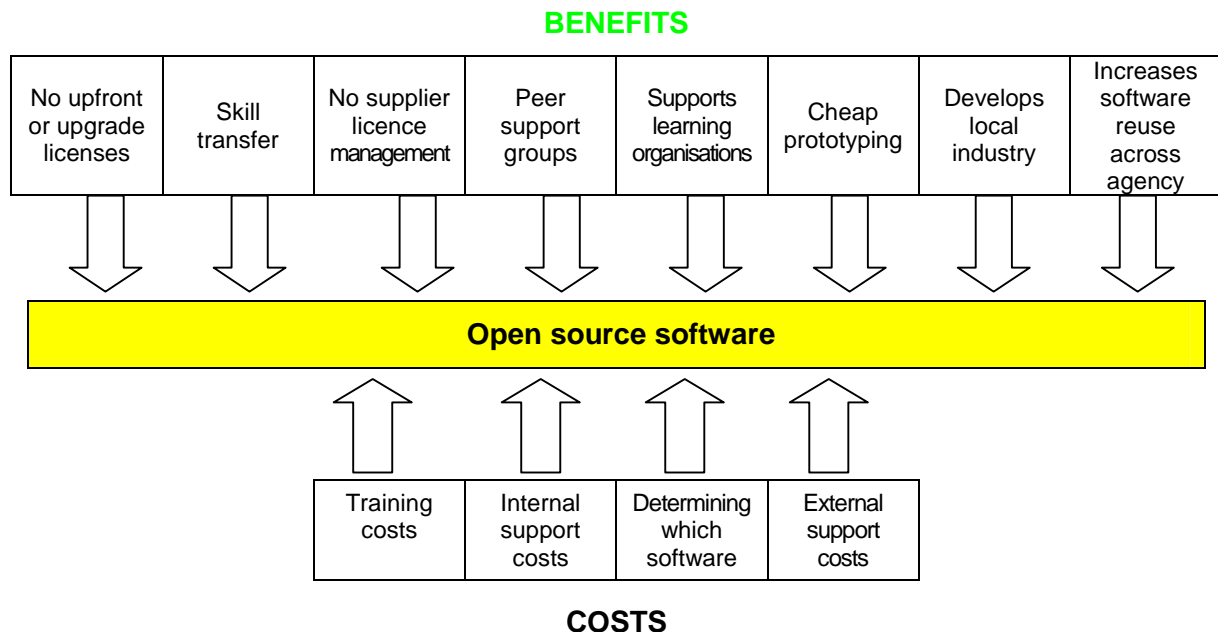


Diagram 5: Costs and benefits of opens source software¹³⁶

¹³³ L. Murphy, Curriculum software: Business Case, DECS (SA) 2003

¹³⁴ Information presented here draws upon R. Simpson, Does open-source software have a place in your IT portfolio? Gartner 2003, <http://asiapac.gartner.com/events/noie.cfm>; some points gleaned from Department of Education, Government of Western Australia, ICT Open source application environment 2003

¹³⁵ *ibid*

Access to technical support is important to schools and systems. Some schools and jurisdictions pay for additional support to that provided through the proprietary licensing agreements. The open source software model means that the software product and its upgrades are available from the Internet and if additional support is required, then that can be accessed from user groups on the Internet, purchased commercially or technical support officers can be provided with on-the-job training.

Limitations

Some of the limitations some users of open source software see are:

- There is no single organisation with a responsibility for supporting it;
- Ease-of-use features tend to arrive later than for commercial products;
- Uncertainty over government intellectual proprietary systems;
- There are a lot of negative perceptions about open source software;
- Familiarity of users with existing proprietary systems.¹³⁷

Minimising risk

Whether the software is open or proprietary, schools and sectors require methods to minimise their risks with acquiring software. One of the most effective ways of doing this requires 'people' rather than 'technical' solutions.¹³⁸ All organisations using IT have to ensure that there are effective IT governance arrangements in place within the organisation.¹³⁹ These governance arrangements have to be thoughtfully and carefully designed with the appropriate declarations of rights management in place. In devolved or distributed systems, clear statements about the roles the central agencies have in relation to the local sites, are required.¹⁴⁰

The following issues also contribute to how an organisation is able to minimise its risks in relation to acquiring software. Each component requires a discussion to determine the best decisions for that particular organisation:

- Are there standards, criteria and guidelines specified and are there mechanisms for ensuring adherence to these specifications?
- Is there an asset register of hardware and software that is maintained and updated?
- What is the correct balance between standardisation and complexity?
- Are policies and procedures regularly reviewed and updated?
- Do end users understand and comply with software licences?
- What tracking mechanisms are in place to ensure licences are adhered to and the organisation is not put at risk?
- Can software and hardware be reused and if so at what cost?
- What is the balance to be struck between the ability to provide technical support and computer down time?¹⁴¹

Cost and benefit

One issue that is both a cost and a benefit of open source software within school education is the scope and amount of software available. One of the issues for schools and sectors is determining which open source software amongst the wide range available has applicability for the schooling sector.

¹³⁶ Diagram draws upon R. Simpson, Does open-source software have a place in your IT portfolio? Gartner 2003, <http://asiapac.gartner.com/events/noie.cfm>; some points gleaned from Department of Education, Government of Western Australia, ICT Open source application environment 2003

¹³⁷ See N. Peeling & J. Satchell, Analysis of the impact of open source software, QintetoQ Ltd, 2001

¹³⁸ *Ibid*

¹³⁹ *Ibid*

¹⁴⁰ *Ibid*

¹⁴¹ See Open source, Open source case for business, supporting documents, 2003, http://www.opensource.org/advocay/case_for_business.php

Policy and practice issues

All states and the Australian Capital Territory Department of Education have IT infrastructure that is largely based upon proprietary software and standards. To move away from that software brings with it issues that have to be considered. These issues include the costs associated with:

- Software transition and migration
- Exit costs from proprietary software contracts
- Expertise
- Cultural change

The question of expertise is the easiest to deal with in policy terms, but to consider these four issues holistically requires determining the total cost of ownership of open source software. This task is beyond the scope of this paper.

CONCLUSION

There is increasing interest in the potential applications of open source software in Australian schools in both the public and the private sectors. Many issues have been raised in this paper and require further discussion. Determining the most appropriate suite of software a school or sector should acquire requires determining the deployment model best suited to the organisational structure; weighing up of the costs and benefits; and managing the risks. Little comparative work has been undertaken in Australia to help inform schools of these decisions. It has been intended that this paper can help develop some shared understandings to inform future conversations on these matters.

APPENDIX ONE

Examples of open source software

The following list is indicative rather than exhaustive. There is a wide range of open source software operating systems and application software.

Operating systems	Linux FreeBSD Debian Mandrake Linux NetBSD
Applications software	OpenOffice StarOffice
Email	Sendmail SquirrelMail Fetchmail
Web applications	Mozilla Apache Jigsaw
Emulators	Kopete
Databases	MYSQL Postgresql
Modelling and Multimedia tools	Gimp K3D Ayam Open Cascade Jcad
Audio	Audacity Soundtracker RadioActive
Middleware	Mico Orbit Omni ORB
Digital library software	Avanti Circulation System Koha open source library system (NZ based)
Palm pilot synchronisation	Wcal

For more information about particular pieces of open source software see http://www.unesco.org/webworld/portal_Software¹⁴²

¹⁴² United Nations Educational, Scientific and Cultural Organization (UNESCO) UNESCO Free software portal, 2002, http://www.unesco.org/webworld/portal_freesoft/Software

Open source software Learning management systems

The following list has been taken from the Commonwealth of Learning (2003) evaluation of open source learning management systems.

	Product	Status	Synopsis
1	ARIADNE www.riadne-eu.org/en/about/general/fees/fees.html	Excluded	Required fees for participation. Could not get into system. Interface in French. Seems to be a collection of tools not clear system. Seems more in the planning phase.
2	Atutor www.atutor.ca	Short Listed Recommended	ATutor is very new. It provides good documentation, ease of installation, and strong potential for development. Strong emphasis on usability. The software is free for non-commercial use
3	Bazaar www.ts.mivu.org	Excluded	Bazaar is a group collaboration product with some basic file manager features. Not strongly course-oriented. Limited user base.
4	Bodington Commons www.bodington.org	Excluded	Limited use at 2 institutions in the UK. Unable to easily examine software or documentation.
5	BSCW bscw.gmd.de/	Excluded	BSCW is a group collaboration tool with basic file management features.
6	CampusSource UNI Open Platform www.campussource.de/org/software/unionline	Excluded	Very limited functionality as yet – more of a campus Personal Information Manager
7	CHEF www.chefproject.org/	Excluded	CHEF is an OKI-compliant product that is quite new. Currently it has minimal course/content management support but may evolve into a leading, full-featured solution.
8	Claroline http://www.claroline.net/	Excluded	Similar to CHEF in its feature list but more mature and with broad user base.
9	Classweb classweb.ucla.edu	Excluded	Simple file manager for classroom websites. Very little LMS

			functionality.
10	Colloquia www.colloquia.net/projects.html	Excluded	Colloquia supports group working and group learning. No Course-oriented features per se.
11	Connexions Project cns.rice.edu	Excluded	Experimental technology not packaged for distribution.
12	CourseWork aboutcoursework.Stanford.edu	Excluded	CourseWork is not ready for distribution outside of its development environment. More of an OKI test bed.
13	COSE Virtual Learning Environment www.staffs.ac.uk/cose	Excluded	Limited adoption and not yet packaged for distribution.
14	Cyberprof www.howhy.com/home/	Excluded	Some web publishing tools, course creation and assessment. It is not widely adopted.
15	DotLRN www.dotlrn.org	Short Listed	.LRN is a mature high performance application in use at MIT. It is more of a collaborative space than an LMS, having only basic file manager facilities. Complex to install.
16	e-education www.jonesadvisorygroup.com	Excluded	Restrictive Open source precludes non-post-secondary organizations from free use. Also has content use restrictions.
17	Eledge eledge.sourceforge.net/	Excluded	Has no significant adoption and no obvious user or software documentation
18	FLE3 fle3.uiah.fi/	Excluded	Fle3 is a web-based learning environment. To be more specific Fle3 is server software for computer supported collaborative learning (CSCL). Offers collaboration, chat, and annotation.
19	Ganeshha www.anemalab.org/commun/english.htm	Excluded	Seems like a full-featured LMS but so far only in French.

20	ILIAS www.ilias.uni-koeln.de/ios/indexe.html	Short Listed Recommended	ILIAS has administration, collaboration, content management, and course management features as well as roadmap to support standards. An excellent candidate.
21	KEWL kewl.uwc.ac.za/sourceforge.net/projects/kewl/	Excluded	The Knowledge Environment for Web-based Learning (KEWL) is a full online courseware system The system only runs on Windows 2000 server.
22	LON-CAPA www.lon-capa.org	Short Listed	LON-CAPA is a full-featured, mature application. Includes content manager. An excellent candidate.
23	Manhattan manhattan.sourceforge.net/index.php?menu=1	Excluded	The Manhattan Virtual Classroom is a full-featured password protected, web-based virtual classroom system that includes a variety of discussion groups, live chat, areas for the teacher to post the syllabus and other handouts and notices, a module for organizing online assignments, a grades module, and a unique, web-based email system open only to students in the class. It is constructed in the C programming language and so will have significant portability challenges. Also not widely used.
24	MimerDesk http://www.mimerdesk.org/	Excluded	MimerDesk is a web-based groupware environment designed for a wide variety of uses such as personal management, computer-supported collaborative learning, carrying out projects, and setting up communities. Its main strengths include a very customizable group system which allows many groups to work simultaneously on a shared database with tools like Calendar, Tasks, Forums, Links,

			<p>Chat, Reviews, Voting, Files, Instant Messages, Profiles, and many more.</p> <p>Seems like a good content and collaboration tool for sharing files but lacks the learning and teaching component.</p>
25	<p>Moodle www.moodle.com/</p>	Short Listed	<p>Moodle is a student-centered course management system designed to help educators who want to create quality online courses. The software is used all over the world by universities, schools, companies and independent teachers. Merits a closer look.</p>
26	<p>OpenCourse www.opencourse.net/download</p>	Excluded	<p>According to the author: "Although it's in production use at one university, I'm not ready to call it production quality for anybody but me. There are basic installation instructions at last."</p>
27	<p>OCW – open courseware Ocw.mit.edu</p>	Excluded	<p>OCW is a long-term project at MIT that will eventually result in a powerful, large-scale solution for course management and content production. It is currently not designed or purposed for distribution</p>
28	<p>OLMS www.psych.utah.edu/learn/olms/</p>	Excluded	<p>University of Utah Dept. of Psychology inhouse Java- based LMS. Limited features and support.</p>
29	<p>OpenLCMS www.Sourceforge.net</p>	Excluded	<p>Not much activity or information on this project.</p>
30	<p>OpenLMS openlms.sourceforge.net/</p>	Excluded	<p>OpenLMS is a Learning Management System (LMS) made at the Dept. of Geography, NTNU. The system is a fully functional LMS with support for group collaboration, file sharing, distribution of</p>

			lectures, etc.. As such it is a tool for distributing lecture notes to groups of students, and also facilitating collaboration for groups of students and teachers. Not much activity – and all in German
	www.opaltree.com	Maybe	This company has an intriguing product under development. Targeted release is August. Potential for collaborative development exists.
32	OpenUSS openuss.sourceforge.net/openuss/index.html	Excluded	Component based, lecture, mail, discussion, chat, assessment and browser tools. ASP Model. Offering unclear. Roadmap dated. Unclear of activity and support, limited documentation.
33	Ripples/Manic manic.cs.umass.edu/research.html#manic2.0#manic2.0	Excluded	Allows for HTML and audio delivery of course. Web content seems dated.
34	Shadow netWorkspace sns.internetschools.org/info/sns2/index.cgi	Excluded	The Shadow netWorkspace project seeks to bring the benefits of advancing internet-based technology and network services to bear on the work of improving teaching, learning and schooling. Focus on community building. Lack of current development activity.
35	Whiteboard Whiteboard.sourceforge.net	Excluded	A small experimental project with no user base of documentation

See Commonwealth of Learning, Commonwealth of Learning Learning Management Systems Open Source, Commonwealth of Learning June 25 2003

APPENDIX TWO

Open source software and private enterprise

A range of companies in the private sector in Australia and overseas use open source software. The following is an indicative list

Private enterprise

- Gerard Industries
- SANTOS
- Shell
- Disney
- Banca Commerciale Italiana
- Deutsche Bank
- Ford
- Alberta Credit Unions (Canada)¹⁴³

Large Vendors

Hardware vendors such as Dell, IBM HP, and Sun Microsystems support the open source operating system Linux. These companies sell Intel-based computer hardware with Linux preinstalled. In addition, these companies offer open source technical support for the Linux operating system. IBM supports Linux on its mainframe (z/OS) and iSeries 400 (OS/400) systems. Linux binaries are supported by Hewlett Packard and IBM on their proprietary reduced instruction set computer (RISC) systems.¹⁴⁴

Major independent software vendors (ISVs) such as Oracle Corporation have ported their software to Linux. Oracle has ported to Linux its database and enterprise resource planning (ERP) applications. Oracle recommends Red Hat for the provision of support services. In 2003, almost all major relational database management systems (RDBMS) run on Linux.¹⁴⁵

Small and medium vendors

- Everything Linux (NSW)
- Cybersource (VIC)
- Cyberknights (WA)
- Linux Servers Australia (QLD)
- Microbits (SA)
- Tekmax (TAS)
- CSM (NT)
- Red Hat (National)

Small vendors across Australia can be sourced from the AUUG site (see <http://www.auug.org.au/>)

¹⁴³ See M. Fisher, Open source software and the role of Linux in the public sector, IBM, 2003; J. Carrigan, Changing the game with Linux, Society of Exploration Geophysicists, San Antonio Texas, September 10 and 11 2001

¹⁴⁴ M. Hubley & N. Muller, Linux: What major IT vendors are doing, Gartner, 2002, <http://asiapac.gartner.com/events/noie.cfm>

¹⁴⁵ *Ibid*

APPENDIX THREE: WHAT IS HAPPENING OVERSEAS?

The private sector and governments around the world are moving towards using open source software.

United States of America

In March 2003 Democrat Phil Barnhart introduced the legislation Oregon H.B. 2892 which would require Oregon's state agencies to consider the use of Linux and other open-source software in information technology procurements. It is currently 'sitting on the table'.¹⁴⁶

Other US States proposing legislation relating to open source software are:

- Oklahoma HB 1627, sponsor Mike Reynolds (Republican), introduced - February 3, 2003, The Text Oklahoma HB 1627
- Texas SB 1579, sponsor John Carona (Republican), introduced - March 13, 2003.¹⁴⁷

Several Federal government departments in the US are investigating or using open source software including the US Department of Agriculture, the US Airforce and the US Department of Defence.¹⁴⁸ Riverdale R-12 School in Portland Oregon is conducting the K12 Linux Project¹⁴⁹

The SchoolForge project was launched in January 2002. It has the aim of promoting 'the use of open source and free software, open texts and lessons, and open curricula for the advancement of education and the betterment of humankind'.¹⁵⁰ The Linux website hosts a site specifically for children, which can be accessed in English, French, Spanish and Portuguese¹⁵¹

Canada

Open source software is central to the *Public Knowledge Project*. The *Public Knowledge Project* is a Canadian research project located at the University of British Columbia in Vancouver. It is intended for anyone interest in exploring how new technologies can be used to improve the professional and public value of scholarly research. Part of the project involves developing open publishing systems using open source software.¹⁵²

United Kingdom

The Office of the E-Envoy in the United Kingdom (UK) has developed a policy addressing the use of open source software within the UK government. This policy indicates that the UK government will consider open source software solutions alongside of proprietary ones. This policy also states that 'the UK government will only use products for interoperability that support open standards and specifications in all future IT developments'¹⁵³

¹⁴⁶ B. Robinson, *Open source on hold in Oregon*, FCW.com, May 9 2003

<http://www.fcw.com/geb/articles/2003/0505/web-oregon-05-09-03.asp>

¹⁴⁷ See San Diego Linux Users Group, 2003 <http://www.sdlug.org/index.html>

¹⁴⁸ C. Kenwood, *A Business Case Study of Open Source Software*, MITRE, 2001,

http://www.mitre.org/support/papers/tech_papers_01/kenwood_software; . Hubley & N. Muller, *Linux: What major IT vendors are doing*, Gartner, 2002, <http://asiapac.gartner.com/events/noie.cfm>

¹⁴⁹ See Riverdale K-12 Linux in Schools Project: <http://www.riverdale.k12.or.us/linux/index.html>

¹⁵⁰ See SchoolForge, <http://schoolforge.net/doc.php?w=pr-jan8>

¹⁵¹ See the Linux for Kids project: <http://www.linuxforkids.org>

¹⁵² See Public Knowledge Project, 2003 <http://www.pkp.ubc.ca>

¹⁵³ Office of Government Commerce (2002) *Open source software. Use within UK government version 1*. 15 July 2002, <http://www.ogc.gov.uk/index.asp?id=2190>

The UK Joint Information Systems Committee (JISC) has initiated an online pilot called *OSS Watch* which provides an advisory service about open source software.¹⁵⁴

Germany

The German government has signed a contract with IBM and the Linux company SuSE to enable government offices to use open source operating systems.¹⁵⁵ The German government has decided to standardise on Linux at federal, state and local levels,¹⁵⁶ and the German Parliament uses Linux for its IT infrastructure.¹⁵⁷

Norway

The Norwegian government has not renewed its contract with Microsoft and is instead going to use open source software.¹⁵⁸

Italy

The Green's Senator Fiorello Cortianna has introduced open source legislation in Italy.¹⁵⁹

France

The French government's Ministries of culture, defence and education use Linux.¹⁶⁰

European Union

The European Union plan, *The Information Society for all eEurope Action Plan*, includes a specific action to promote open source software in the public sector and in egovernment.¹⁶¹ Within the European Union there are several projects using open source software.

Innovative Technology for Collaborative Learning and Knowledge Building (ITCOLE)

The Innovative Technology for Collaborative Learning and Knowledge Building (ITCOLE) project is focused on developing innovative pedagogical models, design principles and technology for collaborative knowledge building in European education. The ITCOLE project includes the euro-cscl.org website. The euro-cscl.org website is a space developed to serve as a community site and access point for resource information for practitioners, researchers and school administrators. Open source software and standards are used on the website.¹⁶²

European SchoolNet

The European Schoolnet is an international partnership of 23 European Ministries of Education. The European Schoolnet is the framework for the cooperation between the European Ministries of Education on Information and Communication Technology in Education and the European network of national, regional and local educational networks. The roles of the European Schoolnet include developing learning materials for schools, teachers and pupils across Europe. It provides information about the educational use of ICT in Europe for policy-makers and education professionals. It acts

¹⁵⁴ Joint Information Systems Committee (JISC), *OSS Watch*, 2003, <http://www.oss-watch.ac.uk/>

¹⁵⁵ See S. Shankland *Linux contract treads on Microsoft turf*, CNET News, 2002 <http://news.com.com/2100-1001-931027.html>; Hubley & N. Muller, *Linux: What major IT vendors are doing*, Gartner, 2002, <http://asiapac.gartner.com/events/noie.cfm>

¹⁵⁶ Hubley & N. Muller, *Linux: What major IT vendors are doing*, Gartner, 2002, <http://asiapac.gartner.com/events/noie.cfm>

¹⁵⁷ See M. Fisher, *Open source software and the role of Linux in the public sector*, IBM, 2003

¹⁵⁸ Associated Press, *Norway says no way to Microsoft*, 2002, <http://www.wired.com/news/antitrust/0,1551,53898,00.html>

¹⁵⁹ See F. Cortiana, *Atto Senator 1188*, <http://www.senato.it/leg/14/Bgt/Schede/Ddliter/16976.htm>

¹⁶⁰ Hubley & N. Muller, *Linux: What major IT vendors are doing*, Gartner, 2002, <http://asiapac.gartner.com/events/noie.cfm>

¹⁶¹ See N. Peeling & J. Satchell, *Analysis of the impact of open source software*, QintetoQ Ltd, 2001

¹⁶² See European Schoolnet, <http://eunbrux02.eun.org/portal/index-en.cfm>

as a gateway to national and regional European school networks. The portal uses open standards to support interoperability, and through the site, open standards and the use of open source software is actively supported. In May 2003 the European Schoolnet, signed a Memorandum of Understanding (MoU) with **education.au limited** and The Le@rning Federation.¹⁶³

India

The Indian Department of Information Technology has announced it wishes to move the whole country to Linux as its 'platform of choice'.¹⁶⁴

Peru

The Peruvian Government has introduced legislation known as the *Free Software in Public Administration Bill*. It decrees the use of open source software in all government systems.¹⁶⁵

Brazil

Brazil has also introduced legislation concerning open source software¹⁶⁶

China

China Post uses Linux to support its distributed network.¹⁶⁷

UNESCO

UNESCO hosts the Free software site
[see http://www.unesco.org/webworld/portal_Software]¹⁶⁸

¹⁶³ *Ibid*; See also http://eun.org/eun.org2/eun/en/About_eschoolnet/content.cfm?lang=en&ov=26295

¹⁶⁴ Orion, E. (2002) *India moving to Linux*, The Inquirer <http://www.theinquirer.net/?article=5767>

¹⁶⁵ D'Empaire, A. *Microsoft's big stick in Peru*, Wired news, 2002

¹⁶⁶ *Ibid*

¹⁶⁷ See Fisher, Open source software and the role of Linux in the public sector, IBM, 2003; Hubley & N. Muller, Linux: What major IT vendors are doing, Gartner, 2002

¹⁶⁸ UNESCO, UNESCO Free Software Portal, 2001,
http://www.unesco.org/webworld/portal_freesoftware/Software

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