Richard Rothwell from the Schoolforge Project gives a detailed practical account of the use of free, open source software and legacy hardware to run an extensive network on a restricted budget at Handsworth Grammar School.

Why pay for your software?

The viability of non-proprietary software solutions for schools.

By Richard Rothwell

The computing department at Handsworth Grammar School is unusual. All of the desktop computers in the department run free and open source software. This means our PCs run GNU/Linux as our operating system rather than one of the proprietary Microsoft operating systems. Instead of using one of the expensive office suites, we offer several of the freely available ones - of which OpenOffice.org is probably the best known. The move towards Linux at Handsworth stems from a number of complex reasons. Here I will attempt to put the story together.

The History

When I arrived at Handsworth in 2002 I carried out a number of audits and surveys. It was clear that the hardware and software were getting old. All seemed likely to need replacement at the same time - and probably in the near future. This was likely to be at considerable cost, though I was aware that the school had no money. One of our main teaching rooms was set up with laptop computers, which for security reasons were chained down. It was soon obvious that these were unsuitable for use in school. They were becoming extremely unreliable and indeed would soon become completely un-serviceable. The problems were to do with the power connectors and the expensive components. For example, a new keyboard for a desktop costs less than £5, for a laptop it can cost well over £50. The survey, the hardware issues and the lack of funds left me with a problem; I started looking for solutions.

At the same time I was expected to contribute to the school's plans to achieve Specialist Status in Maths and Computing.

Problem Statement

The major conclusions of the surveys were:

- the laptops would not survive another year

- the majority of the PCs could not be economically upgraded to a newer proprietary operating system.

- the Network Servers were running Microsoft NT4 that would no longer be supported beyond 2004.

- the school did not have enough computers, either in the computing

department or throughout the school.

Much of this was crystallised when Microsoft made an announcement indicating that the newest version of their office suite would not run on earlier versions of their operating systems. I am not prepared to offer my opinion of this decision in writing. Additionally, pupils were beginning to bring in files from home computers in formats that the school's software could not handle. This was only going to get worse.

Needs Specification

At this stage I constructed a needs specification, the list stated:

- More computers in the department and around the school.

- Minimal capital outlay - as we had so little money.

- Maximum control over future spending - I wanted a solution where it was possible to decide when to replace or upgrade the systems.

- The software should offer a complete range of teaching applications and compatibility with de-facto standard file formats - eg Microsoft Word document, Microsoft Excel spreadsheet, Adobe Acrobat portable document and so on.

- Once the new system was in place, maintenance should be low .

Investigation

I then investigated the market for possible solutions. The major choices were:

Upgrade the existing systems

Proprietary Operating System (eg Microsoft Windows XP):

- This would offer compatibility.

- This would be expensive upfront.

- Future expenditure would be completely outside the control of the school.

- This was the safe option - it used to be said that no-one ever got fired for buying IBM...

Open Source Operating system (eg GNU/Linux) with on the desktop:

- Much hardware would need upgrading.

- Maintenance of the workstations would need to be addressed.

- Gaining or importing expertise would be necessary.

- This was an unusual option and there would be many problems to overcome.

Make no changes

- The costs of maintaining the equipment would steadily rise - particularly with the laptops.

- The hardware would eventually have to be discarded - and this would probably happen for most of the hardware at the same time.

- Software compatibility problems would rise steadily.

- There was no need for any capital

expenditure.

around the school

Proprietary Thin Client solution - eg Citrix:

- The costs of purchasing the software and hardware would be considerable.

- Control over the systems and future developments would be out of our hands.

- Upgrade paths and other issues were unclear.

- This was a documented and well known path.

recycling old machines that were lying around the school, purchasing cheap hardware and getting donations would allow us to get a lot of machines in use as thin clients.

Minimal capital outlay

the servers could be standard home specification PCs.

Maximum control over future spending

Open Source Thin Client solution - eg LTSP:

- Existing, very cheap or currently unused hardware could be recycled as thin clients

- Client maintenance costs would in the long term be very low.

- Upgrade paths are clearly planned and under our control.

- Once the clients are configured they will work until they fail physically.

- We would need to gain or import technical expertise.

- This was an experimental and risky route to follow.

the mode of development of GNU/Linux meant that we could choose to upgrade kernels and hardware when we wanted to.

Teaching applications

most applications we required were available as Open Source offerings.

Compatibility with de-facto standard File Formats

most standard files could be read and written.

Once in place maintenance should be low

the client machines could be
physically swapped out on hardware failure - software maintenance would be centralised and minimal.

Decision Stage

Referring to the needs specification I felt that the best fit was the LTSP option. Even considering the risks, it would offer:

More computers in the department and

From there...........

Prototypes

In the winter of 2002/3 two pupils, Chris Powell (year 12) and Sam Buckler (year 11), built a prototype system as proof of concept. This was demonstrated at a small meeting in the spring of 2003 and soon after a presentation was made to the governors. The presentation was done using purely open source software.

Several more experimental systems were put in place and over the the next few months. We were also helped by Sun, who reviewed our system design and made several suggestions for improvements. Plans were put in place to:

- sell the laptops that were still reliable.

- seek donations of computers from other schools and organisations.

- assess the viability of linking the LTSP and MS Windows NT networks.

- purchase the new servers.

LTSP

LTSP is an add-on package for Linux that allows you to connect lots of low-powered thin client terminals to a Linux server. Applications typically run on the server, and accept input and display their output on the thin client display. These thin clients have little or no software on them. Two common solutions are PXE or Etherboot. Both of these allow a standard PC with a network card to be configured as a LTSP terminal in a matter of minutes. Once booted the client downloads a local version of Linux which runs in memory. With the thinnest of clients, all that the desktop machine does is run the X Session which runs the monitor, sound card, keyboard, mouse, etc. The application

processing is then done on the server.

Schoolforge

In April 2003 APU (Anglia Polytechnic University) hosted a one-day conference which attracted delegates and speakers from across the UK to hear representatives of the government (BECTA, Office of the e-Envoy and DFES) and experts in the field. Attendees also shared information on the issues and benefits of using freely-licensed software in schools and openly sharing the resources created with each other. The event was attended by teachers, network managers and special advisors to the government as well as academics and technicians from educational and commercial organisations.

The day focused on both the technical and philosophical arguments for openness and sharing in education. Case study presentations highlighted the use of free operating systems and free software applications to minimise administration, cost and computer hardware turnover. Keynote speeches by Prof. Diana Laurillard (DFES) and Prof. Stephen Heppell (Ultralab) concentrated on how adopting principles of open learning can help teachers and learners alike.

The on-site network of Linux PCs provided a platform to show examples of education-specific software that has been developed worldwide and was warmly received by delegates who took the opportunity to get experience of applications which are free to use and free to distribute.

Following the meeting Schoolforge UK was formed. Schoolforge brings together all those interested in non-proprietary solutions for education. Professor David Hargreaves, Chairman of Becta, delivered the keynote

speech on "Innovation and ICT: a personal view" at the FLOSSIE Conference 2004. Prof. Hargreaves graphically contrasted various approaches to innovation, leading progressively to his vision of an open source network of schools and teachers that would produce a peer-to-peer system of knowledge management that is decentralised, distributed and disciplined.

Schoolforge UK's mission is to bring together individuals and organisations that advocate, use, and develop open resources for UK schools and colleges. Amongst other activities we are involved in:

- Advocacy - Promoting the use of freely-licensed resources in education

- Case Studies - Reporting success stories and experiences

- Free, Libre and Open Source Software solutions for Education - Showing open resources that can be used in place of common proprietary products

- Open Educational Resources - Tailored for the English National Curriculum and other UK equivalents.

- Useful Resources - A repository of beginners guides, Howtos etc. as a jumping-off point for new users.

- Virtual Learning Environments - Weblogs, course delivery systems, intranet solutions.

Our next conference will be early in 2005.

The Changeover

As with all projects of this size and nature, there were problems encountered. Certain decisions that were made early on were not optimal, and this has caused problems which are only now being completely resolved. That said, by the start of the Autumn Term 2003 we had two rooms working well using LTSP and continued to teach effectively within the department. The project survived a change of technician in late 2003, and we now have a wealth of in-house expertise and contacts with others who are working in this field.

Our desktops offer a wealth of applications. Instead of one web browser, we can offer three or more. There is a choice of word-processor and spreadsheet applications for the pupils. Should a new application be required it need only be setup on one of the servers and it is available across all the terminals. Many of these applications are also available for Microsoft operating systems. This means that we can legally and freely distribute the software that we use at school to our pupils. The equality of access that this offers is refreshing.

The most difficult feature of the change has been the fear, uncertainty and doubt of the staff. This is due to be addressed over coming months with training and support. Were I to do the project again this would be addressed at a much earlier stage.

Current Status

In July 2004 we achieved Specialist Status - with the computing part of the bid focused on the use of Open Source Software. The key components of the computing part of our bid are published on the wiki. Interestingly, another school in Birmingham which gained the status at the same time gave us 20 computer systems which they could not use in their planned upgrade of proprietary operating system.

Major Objectives Completed

We now have three rooms running LTSP. We have six servers sharing the work load. These are serving around 90 clients. We recently purchased 120 second-hand computers to upgrade the terminals. This was partly for cosmetic reasons, but also to allow us to experiment with running local applications. This means that certain application can be run on the client instead of the server. There are benefits to running applications on the workstation.

- Reduces the load on the server. In large networks with memory intensive applications, such as web browsers, running the application on the workstation can provide better performance, as long as the workstation is powerful enough to handle it.
- Runaway applications will not affect other users.
- Sound support is much easier to configure when the application that plays the sound is running on the workstation.

This purchase included 100 Pentium III 533 MHz Compaqs with 128MB of RAM. The total bill was under £2,000.

The next part of the project is to migrate from the Microsoft NT servers to using purely Linux servers for our pupils' user areas. Martin Wooley, our senior technician has made huge strides in integrating the NT user areas, and the pupils have a single log on which mounts their user areas from the NT systems. He is now also using NIS (Network Information Service) to allow pupils to log on to any server and mount their Linux user area.

Plans

We are developing this Internet based wiki resource for pupils and staff to build and share knowledge on. Wikis allow users to edit web pages instantly on-line using a simplified mark-up language. Each pupil has an account on the wiki and is encouraged to do as much as possible of their work on it. They are extremely low maintenance - forgotten passwords are e-mailed out at the click of a mouse.

The computing department uses the wiki extensively. Currently its uses include:

- Publishing timetables, resources, homework and lesson records.
- Allowing pupils to work easily from school or home.
- Documenting the development that we are doing.

Our successful specialist bid for Maths and Computing Status states that we will have departments making resources available on-line - over the next 18 months we plan to have the Maths department publishing material in a similar way, with the rest of the departments following.

We are looking to use the software more effectively in our teaching - in particular I want to move the GCSE and A-level project work away from the proprietary databases that are currently being used to an Open Source solution - there are a number of solutions we are looking at - OpenOffice has database functionality built in and we are working on a project to improve the ease of use of this. For sixth form projects we plan to move to the LAMP platform - which uses four key open source solutions Linux, Apache, MySQL and PHP. This is used on many thousands of Internet applications.

As part of our Specialist bid we will next term have pupils rebuilding computers in an

after school activity. This will extend further the equality of access that is central to this whole process. The pupils will be expected to build two computers - one for a primary school or other good cause, one for themselves.

Several other projects are under development at the moment. These include:

- An ultra-low cost data logging system to be built by each pupil using a 555 timer as a resistance to frequency converter and the microphone input of the computer. This will be supported by a set of free data logging tools available as Open Source.

- A Knoppix type bootable CD that contains a set of music software. For example, Rosegarden offers a free audio and MIDI sequencer, score editor, and general-purpose music composition and editing environment. This could easily convert any modern PC into a composition tool at home or at school for almost no cost.

Costings

We have been part of the Becta Total Cost of Ownership (TCO) project. The preliminary results of the work indicate that our TCO is appreciably below that for proprietary software. This is allowing for our higher technical support costs. The technical costs are in many respects a one off cost. The work that we are doing at Handsworth is necessarily covered by the standard terms of Free and Open Source development - that is we are duty bound to publish our work and make it freely available. We have contributed to the knowledge base which means that we share it with others and publish it on our wiki.

To demonstrate just how low these costs can be, we are offering a bundle of computers to other organisations - particularly targeting primary schools and voluntary organisations. Part of our specialist school bid was to employ a technician who was 50% allocated to working for partner organisations. Precise costings obviously depend on the market for second-hand computers and other factors but we estimate a 30 seat network could be provided for around £6,000. This would cover:

- 30 refurbished client computers with 17" CRT monitors
- Two servers providing web browsing, standard office applications and educational software (for example The KDE Edutainment Project)
- Sufficient storage for user data or, if necessary, use of and authentication against an existing network system
- Training and a year's support

All of this would be delivered using existing and proven technologies and would be fully documented so that the school was in no way tied to using any particular provider to maintain the system. I am sure that many other organisations or companies would be prepared to match or beat these prices.

Conclusion

Once installed the thin clients can be expected to have a very long useful life. At Handsworth we are now planning not only to expand the number of computers throughout the school, but to upgrade monitors and so on. With the ability to roll out class sets of computers at these prices we are now in a position to offer departments and individual teachers the chance to migrate all or most of their teaching into computer rich environments. I greatly look forward to this development and see it as our next challenge.

Richard Rothwell

FLOSS GLOSSARY

Free, Libré and Open Source Software

Some supporters of the idea use the term free software and some use Open Source (http://www.opensource.org/docs/definition_plain.php). Mostly, both groups mean software that you are free to:
- run for any purpose
- study how it works and adapt it to your needs
- copy and redistribute
- improve, and release improvements to the public so that the whole community benefits

GNU/Linux

Though we often refer to the project as Linux this is not precisely the case. There are other Open Source operating systems such as FreeBSD (http://www.freebsd.org/)

This comes from the Linux website:

Linux is a free Unix-type operating system originally created by Linus Torvalds with the assistance of developers around the world. Developed under the GNU General Public License, the source code for Linux is freely available to everyone.

http://www.linux.org/

The following comes from the GNU website:

Many computer users run a modified version of the GNU system every day, without realizing it. Through a peculiar turn of events, the version of GNU which is widely used today is more often known as ``Linux'', and many users are not aware of the extent of its connection with the GNU Project.

There really is a Linux, and these people are using it, but it is not the operating system. Linux is the kernel: the program in the system that allocates the machine's resources to the other programs that you run. The kernel is an essential part of an operating system, but useless by itself; it can only function in the context of a complete operating system. Linux is normally used in a combination with the GNU operating system: the whole system is basically GNU, with Linux functioning as its kernel.

http://www.gnu.org/

OpenOffice.org

OpenOffice.org produces a free office suite. The organisation has the following mission

statement:

To create, as a community, the leading international office suite that will run on all major platforms and provide access to all functionality and data through open-component based APIs and an XML-based file format.

Further information and downloads are available from:
http://www.openoffice.org

Control of expenditure

I was once asked by my Headteacher what I could do for my department with half-a-million pounds. My response was "Panic". I went on to explain that I would need to have money available in three to five years to upgrade the hardware. Using the conventional 'Wintel' (http://en.wikipedia.org/wiki/Wintel) deployment this is the life of the computer - and the cost of installing a system need to include uncertain future upgrade costs. Many schools that have invested heavily in computers have experienced this problem. The option described in this article does not have this problem as once the thin client will run the X session it will continue to do so until it physically fails.

Thin Clients

Using various techniques it is possible convert conventional PCs into thin clients. These download all of the software that they run over the network when they boot up. With modern servers and networks this is often quicker that booting from a local hard disk.

Several manufacturers now produce workstations without any moving parts to be deployed as thin clients. These have an extremely long life as the power supply fan and the hard disk are the two main points of failure in a modern PC. Many thin clients designed for proprietary systems can be converted to work with LTSP and firms like DisklessWorkstations (http://www.disklessworkstations.com) produce systems specifically for LTSP.

Rosegarden

As well as the generic office type applications, many people are developing specialist applications under Open Source. Sourceforge (http://www.sourceforge.net) is the place were many of these are posted. Rosegarden is a music application. To quote from their website:

"the closest native equivalent to CubaseÂ® for Linux" is " Sound on Sound

Rosegarden is a professional audio and MIDI sequencer, score editor, and general-purpose music composition and editing environment.

Rosegarden is an easy-to-learn, attractive application that runs on Linux, ideal for composers, musicians, music students, and small studio or home recording environments.

http://www.rosegardenmusic.com/

Knoppix

This comes from their website:

What is KNOPPIXÂ®?

KNOPPIX is a bootable CD with a collection of GNU/Linux software, automatic hardware detection, and support for many graphics

cards, sound cards, SCSI and USB devices and other peripherals. KNOPPIX can be used as a Linux demo, educational CD, rescue system, or adapted and used as a platform for commercial software product demos. It is not necessary to install anything on a hard disk. Due to on-the-fly decompression, the CD can have up to 2 GB of executable software installed on it.

http://www.knoppix.org/

Equality of Access

Handsworth Grammar draws its pupils from a number of areas with extreme measures of deprivation. We believe that all of our pupils should be given as much help as possible. We make efforts to open our computing facilities to pupils, concentrating on those who do not have home computer access. We do not believe that parents should be pressured into obtaining copies of expensive proprietary software to allow their children to use the same software at home as at school. Through our recycling programme we are hoping to equip more of our pupils with home computers, these will be running purely free software. We are also looking at methods of getting cheap or free Internet access into the community.

LTSP

Jim McQuillan has masterminded the award winning Linux Terminal Server Project. The story of how Jim came to produce LTSP is on the website.

http://www.ltsp.org

The K12LTSP distribution is specifically aimed at schools:

http://www.k12ltsp.org/

Total Cost of Ownership

There is much argument over the best ways of measuring TCO. Many different reports appear to contradict each other. I believe that a better measure may be "Return On Investment" - that is what can you get for spending Â£6,000. The final report from Becta on their understanding of the TCO at Handsworth should be out before this article and will be published on our wiki.

The KDE Edutainment Project

This is from their website:

We are developing high-quality educational software for the K Desktop Environment. Our primary focus is on schoolchildren aged 3 to 18, and the specialized user interface needs of young users. However, we also have programs to aid teachers in planning lessons, and others that are of interest to university students and anyone else with a desire to learn!

http://edu.kde.org/

Professor Hargreaves - Chair of Becta

The following quotes come from his presentation to the Schoolforge UK Conference 2004:

"Innovation is best achieved through collaborative networks"

"The same networks are the most effective way of transferring the emergent good practices"

You can view Prof. Hargeaves' slides at

http://www.schoolforge.org.uk/flossie/hargreaves.ppt

Wiki

The following comes from http://wiki.org:

Wiki is a piece of server software that allows users to freely create and edit Web page content using any Web browser. Wiki supports hyperlinks and has a simple text syntax for creating new pages and crosslinks between internal pages on the fly.

Wiki is unusual among group communication mechanisms in that it allows the organization of contributions to be edited in addition to the content itself.

Like many simple concepts, "open editing" has some profound and subtle effects on Wiki usage. Allowing everyday users to create and edit any page in a Web site is exciting in that it encourages democratic use of the Web and promotes content composition by nontechnical users.

There are many Wiki implementations and at Handsworth we use 'MoinMoin' - http://moinmoin.wikiwikiweb.de/

X Windows

X Windows is a Open Source windowing system that is used on Linux and other operating systems. The system includes a standard library of routines that can be used to develop GUI applications. The system also includes standard utilities like xclock, xcalc, xeyes, etc.

X Windows is now developed by the X.Org Foundation http://www.x.org

LAMP

LAMP is an acronym for a set of free software programs commonly used together to run dynamic Web sites:

- Linux, the operating system;
- Apache, the Web server;
- MySQL, the database management system (or database server);
- Perl, PHP, and/or Python, scripting languages.

Though these programs were not designed specifically to work with each other, the combination is popular because of its low cost and the ubiquity of its components (which are bundled with most current Linux distributions).

Support is available from many places including http://www.lampware.org/

PXE Boot

In this configuration the network card or PC has PXE built into it, then you can use that to load the Linux kernel. PXE is a bootrom technology, similar to Etherboot or Netboot.

All that is required is to enable the PXE bootrom on the system. You may also need to change the boot device order in your BIOS, to make "Boot from LAN" the first choice, rather than booting from the floppy or the hard disk.

Etherboot / Rom-o-matic

Etherboot is a software package for creating ROM images that can download code over an Ethernet network to be executed on an x86 computer. Many network adapters have a socket where a ROM chip can be installed. Etherboot is code that can be put in such a ROM.

-- Ken Yap

An alternative to burning a ROM is to store the image on a local hard or floppy disk and load this on boot.

http://www.etherboot.org/

The Simpsons

It is conventional to name sets of servers under some strategy. Research Machines used birds of prey and Freeserve use Pokemon Monsters.

It was decided that we would use Simpsons characters. They would be ideal - as there were a lot of them and the team liked the Simpsons. So far   Handsworth Grammar has LTSP servers named:

> Bart
> Lisa - who does most of the printing
> Homer
> Marge
> Apu
> MrBurns
> Maggie
> The Intranet Server is called 'Comic'
> - though technically it is
> ComicBookGuy.

Schoolforge UK	http://www.schoolforge.org.uk
Handsworth Grammar School wiki:	http://www.openhgs.org/moin.cgi /
Sun Microsystems:	http://www.sun.com
Novell	http://www.novel.com
K12 LTSP:	http://k12ltsp.org/
Linux Terminal Server Project :	http://ltsp.org/
OpenOffice:	http://www.openoffice.org/
Mozilla:	http://www.mozilla.org/
GNU Image Manipulation Program:	http://www.gimp.org/
The OpenCD project:	http://theopencd.sunsite.dk/