Experiences with CDD's: Centrally managed Skolelinux installations at many schools

Knut Yrvin – Skolelinux/DebianEdu

April 12th 2006

The Norwegian Ministry of Education and Research has funded a report about free software in schools. It covers planning and deployment of Skolelinux/DebianEdu that currently includes 234 Norwegian schools, 33,000 client machines, and 101,000 pupils and teachers. It covers technical issues, economics and organisation. There is also some feedback on how the teachers use free software in their teaching.

The main conclusion is that no pedagogic, technical, or economic objections to using free software in schools remain valid. The numbers show that the municipalities save more by running and maintaining ICT equipment centrally at many schools. The savings are considerably larger with GNU/Linux then with Microsoft Windows. Market prices show that the most cost efficient alternative is provided by Skolelinux diskless workstations. These are at least 40% cheaper to operate than traditional workstation pools (with thick clients).

Experiences from the municipalities show that running thin clients (LTSP) is more cost efficient than thick clients because it increases the lifespan of the hardware. Surprisingly, the cost of running graphical terminals such as Citrix is the most expensive solution. It is at least three times more expensive than Windows thick clients when comparing prices in the market. By using graphical clients such as Free NX the schools would incur approximately the same expenses in operating the system as with Citrix.

The ICT coordinators in the various municipalities say that there are considerable challenges in introducing computer tools into schools. The management at every school must establish a maintenance regime and the teachers must learn to use computer tools actively in the learning process. These activities have nothing to do with the operating system in use, but the schools running free software can afford more equipment, and the lower cost of maintaining the system frees more resources to be used by teachers in the learning process.

Table of Contents

Methods

We have used three qualitative methods to gather information for this report. The first method is called action research. Together with the Municipality in Oslo we have analysed the use of DebianEdu/Skolelinux as an enterprise solution for all their 175 schools. The second method was to interview the municipalities about their experiences in running Skolelinux and other free software solutions in schools. The third method was to collect prices in the market both for Microsoft Windows solutions and Skolelinux solutions.

This table shows the municipalities that reported their experiences with centrally managed free software installations at many schools.

Municipality or City council	Number of locations	Number of users	Number of client machines in 2005	Planned number of client machines in 2008
Hurum	9	1700	200	500
Kongsvinger	9	2300	450	800
Nittedal	10	3200	506	1093
Oslo	175	75,000		25,931
Akershus	31	17,000	6000	6600

1 Client technology

There are many more client technologies than thin clients, graphical clients, and workstations. There are also diskless workstation, laptops and programs running in a web-browser with Macromedia Flash or Java. And to complicate the matter even more, There are a variety of combinations of the different client technologies.

To get a better picture of the characteristics of client technology, we have made a short list of the pros and cons of using the different solutions. The reason for this is to know whether the clients deliver what is required when used by pupils in the classroom as a tool for various tasks.

Skolelinux thin clients: Employed with reused computers from 1995 (133MHz CPU) as thin clients with preferably PXE-boot on the network card. No hard disk is required. Requires relatively powerful servers to serve 50 thin clients (dual CPU, 4GB RAM, 100 Mbit/s network) on a switched 100 Mbit/s network.

(+) Gives new life to old reused machines. No need to install software on the client. Software is installed centrally on the servers.

(+) Provides a unified infrastructure to users. The clients have reasonable support for graphical applications including sound support. Newer thin client solutions even support USB memory pens, digital cameras and other devices.

(-) Needs more (powerful) servers than other solutions, but not as much as graphical Citrix or NX terminal solutions

Skolelinux diskless workstations: Use of reused machines from the year 2000 and newer (> 450MHz CPU/256 MB RAM). A hard disk is strongly recommended. Supports DVD, USB memory pens, and other peripherals. A server can support 150 clients on a 100 Mbit/s switched network.

(+) Gives life to newer reused machines, and is also suitable for brand new machines. No need to install software on the clients. Software is installed on one server.

(+) It gives a single architecture solution with the lowest maintenance cost

Skolelinux workstations: Reuse of newer PCs from year 1997 (233MHz CPU/128MB RAM). It requires a local hard drive. Needs one server for network services as home directory, print, Internet etc.

(+) Few servers needed

(-) Requires maintaining and updating software on every client machine

Windows workstations: Reuse of newer PCs from year 2000 (450MHz CPU/256MB RAM). It requires a local hard drive. The client machines should be of the same type and same production month to be easily managed with software updates and such. The alternative is to use many software images for industrial update of software when security patches and such are rolled out. This requires more work to adjust the software for the different client types. Needs one or two servers for network services such as file service, print, Internet etc.

(+) Few servers needed

(-) Requires maintaining and updating software on every client machine

(-) Needs identical client machines to keep the maintenance cost low.

Skolelinux graphical terminals; with NX technology. It is possible to reuse machines from 1995 and newer (133 MHz CPU). The requires relatively more powerful servers, and more bandwidth to the schools e.g. when the servers are located remotely. The schools also need a local server for software maintenance on the client machines as well. In practice the graphical terminals have to be maintained as workstations with local software. In addition the user applications run on remote servers, resulting in two structures for software maintenance and extra use of servers and network capacity.

(+) Give new life to older hardware

(-) More servers needed and you'll have to maintain software on every client. There are two separate ways of distributing software.

(-) Limited support for sound and graphical applications such as video clips and small games, especially when the servers are placed in a central location remote from the school.

Windows graphical terminals: With NX, Citrix or rdesktop technology it is possible to reuse machines from 1995 and newer (133 MHz CPU). This requires relatively powerful servers, and more bandwidth to the schools when the servers are remote. The schools also need a local server for software maintenance on the client machines, that in practice is a workstation with a graphical client. It has almost the same characteristics as graphical terminals with Skolelinux.

(+) Give new life to older hardware

(-) More servers needed and you'll have to maintain software on every client. There are two separate ways of distributing software.

(-) Limited support for sound and graphical applications such as video clips and small games, especially when the servers are placed in a central location remote from the school.

Skolelinux laptops: Use of newer PCs from year 2000 (233MHz CPU/128MB RAM). It requires local harddrive. Needs one server for network services as home directory, print, Internet etc.

(+) Few servers needed

(-) Requires maintaining and updating software on every client machine.

(-) Introduces additional security considerations.

(-) Laptops are expensive to maintain because of the rough use for the machines that gives short lifespan.

This table gives some recommended settings for different types of clients. But first we have to remark on the minimum requirement. It is totally possible to run Microsoft Windows 2000 or Debian Woody on a PC with 64 MB RAM. But it is not usable with an office suite, web browser and a email client. Even with 128 MB RAM on a Windows 2000 PC we have experienced warnings or rejection when printing PDF-formatted documents. ICT operators say the virus scanner uses memory and CPU power. So here is the recommended minimum requirement for hardware that provides useful functionality.

System	Skolelinux thin client	Skolelinux PC [1]	Skolelinux diskless workstation	Windows 2000 PC [1]
CPU	133 MHz	233 MHz	450 MHz	450 MHz [2]
RAM	32 MB	128 MB	128 MB	256 MB
Harddisk	-	1.2 GB	0.5 GB [3]	2 GB
Introduced	June 1995	May 1997	August 1999	August 1999

1. Could also be used as a client for graphical clients as Citrix, Free NX or rdesktop.

2. Needs more CPU power to handle the virus scanner

3. Small harddisk for local swap is highly recommended

The maintenance and operational cost for a computer network depends on the number of concurrent users and the number of machines and services in use. The routines for software installation and updates have an effect on the operating and maintenance costs. The number of servers also affects the maintenance cost.

1.1 Software

The selection of software varies widely between users. Some schools have up to 80 different software programs installed on the system. Others have started with 20 and increased it to 50 after different requests from the teachers. Some municipalities have also installed 7-8 Windows applications that are run with Wine on the Linux thin clients.

The numbers of free software programs for use in schools are increasing. Often it may even seem that there are too many programs available. Many ICT coordinators have to work to reduce the number of programs. It is also a significant trend that pupils use the web browser a lot. The browser is probably the most important tool among computer programs.

The numbers of user programs that only support one operating system is decreasing. Important examples are FireFox and OpenOffice.org that replace proprietary software. Other programs for use in schools are delivered as applications for the web browser. The vendors cannot overlook the fact that the use of FireFox is increasing, and they recognise that they must support different platforms to avoid losing market share.

When it comes to integration there are two important issues. The first is about using OpenDocument file format. A lot of pupils have access to their parents' PCs at home. One or both parents may have a PC from their employer with Microsoft Office, and if the parents won't allow the pupil to install OpenOffice.org on their

PC that presents some obstacles to use of OpenDocument. There are two strategies to work around this. The one is to set Microsoft Word as the standard format when saving in OpenOffice.org at the schools. The second is to explain to all the parents how they should handle this issue. Secondary schools save with OpenDocument as the standard because older kids are more experienced in handling different file formats compared to younger pupils.

The other integration issue is combining different Linux-distributions or integrating with Microsoft Windows. Experiences show that it is really easy to connect servers with K12LTSP into a Skolelinux network. The same for Windows PCs which can be connected to the Skolelinux servers with SAMBA out-of-the-box. The City Council of Akershus has a Windows network with Active Directory, and they connect Skolelinux thin client servers to that net with a tailored SAMBA connector made for all their 31 schools. That way they can reuse a lot of client hardware that would have to be thrown away if they had to run only Windows. Also Macs from Apple can be connected to the Skolelinux net following a simple procedure. There are also solutions to connect Skolelinux thin client servers to a net based on SuSE/Novell. This table gives an overview of different client solutions that can be easily integrated into a Skolelinux network:

Server solution	«Client solution»
Skolelinux	Skolelinux Lessdisk Workstation (LTSP)
Skolelinux	Skolelinux thin clients (LTSP)
Skolelinux	Skolelinux Workstation
Skolelinux	Windows Workstations
Skolelinux	Free NX (Citrix)
Skolelinux	Mac OS X
Skolelinux	K12LTSP (LTSP server)
Windows 2000/2003 Server with Active Directory	Skolelinux thin client server
Skolelinux	Linux laptops (Kubuntu, Skolelinux, etc.)
SuSE Novell with eDirectory	Skolelinux client server

Remember that laptops are expensive to maintain

The last technical issue is that OpenOffice.org, FireFox and some of the windows systems are bloated. This results gives in more expensive memory usage on the servers and the client machines without giving real usability. Some of the municipalities have changed their Windows Manager to ICEwm. Others have replaced OpenOffice.org with Koffice to get an easier to use editor when writing short text documents. The teachers say it is not a big problem.

The pupils don't really need a fully fledged office suite made for office employees when using ICT tools in lower grades. Most of the pupils uses computers for something other than using spreadsheets and presentations. This is the same situations for grown-ups. Most the work done with computer tools at the workplace is done by tailor made professional tools[1] with 42% in the service oriented sector and 89% in the industrial sector. 15% of the time when using the PC is used on a word processor and 2% of the time on a spreadsheet. So the office application are used 17% of the average time on 2 h:15 min spent in front of the computer.

The pupils use computers to make music, sending drawings to school classes abroad, and to learn to write (decode the words). So here lightweight technologies meets usability for pupils in the lower grades.

To sum up the situation with software. Some schools use a lot of free software. But the real killer application is the web browser with different online tools tailor made for teaching. Second comes the office application. That's because a lot of teachers believe the pupils needs to learn an Office suite, but a lot of teachers prefers more lightweight applications. It is issues with handling OpenDocuments at the schools when the pupils parents has a job computer at home with MS Office. This has to be addressed. Experiences from most of the municipalities and city councils is that they integrate different solutions in a cost efficient way.

The first one is that more and more applications are made platform independent by serving them through a

---

[1]A Journal du Net: http://solutions.journaldunet.com/0409/040915_etude_postedetravail.shtml

web server or that applications is usable with platform independent libraries (Qt, Gtk#, Java).

1.2 Investments in equipment

This table shows the real investment in terminal technology and servers in three of the municipalities. The cost of building the network and switches are not included. But the cost for every connection is pretty standard with 255 Euro for every PC, that gives cost at of 54 Euro annually over a 5 year period (with 2% interests).

Hardware investments to 2005

Art	Nittedal	Hurum	Kongsvinger
Client machines (amount)	# 506	# 200	# 450
Servers (amount)	# 11	# 10	# 20
Purchase of reused client machines	17,818	8,909	26,727
Purchase of new client machines	18,327	30,545	45,818
Purchase of new servers	75,568	26,600	63,636
Software Licences			
Hardware investments	111,713	66,054	136,181
Network switch, electric switch	128,799	50,909	114,545
Training cost of ICT contacts and operators	7,636	2,545	6,873
Total	**248,148**	**119,508**	**257,598**
Hardware and training for each client	**236 Eur**	**343 Eur**	**318 Eur**
Network switch, electricity each client	**255 Eur**	**255 Eur**	**255 Eur**
Annually cost over 5 year	**104 Eur**	**127 Eur**	**121 Eur**
Euro (100 EURO = 785.72 NOK)	7.86		

The municipality of Nittedal has the lowest investment cost in client hardware compared with the number of clients. The reason for this is that they have reused more equipment than the other municipalities. They do a bigger effort in getting reused PCs from the administration, install network cards with PXE (Preboot eXecution Environment (Intel)). This is done by the local ICT contact at each school. Other municipalities does this work with their central staff at the ICT service at the town hall.

The ICT service in the different municipalities also report the prices of hardware in the marketplace. Graphical terminals tailor made for Windows cost between $381 - 445$ Euro (without a monitor). A tailor made Linux terminal cost 234 Euro with a reused monitor. Reused client machines cost between $115 - 210$ Euro with monitor.

Adding on a new server and the necessary switches you get a package that can be bought with Skolelinux out of the box. Solution prices from the InOut[2], a reseller of reused computers to schools with server(s) and switches:

Skolelinux solution with 100 complete clients	Economical package with 10 complete clients
2 servers (new). Installed and configured	1 server (new). Installed and configured
# 100 client (PC, monitors, keyboard, mouse)	# 10 client (PC, monitors, keyboard, mouse)
Network switches (reused)	Network switches (reused)
Pedagogic software	Pedagogic software
Price for the package (w/o wat) 24,945 Eur	Price for the package (w/o wat) 3,169 Eur
Price for each client (w/o wat) 249 Eur	Price for each client (w/o wat) 317 Eur

In Norway also FAIR[3] (Fair Allocation of Infotech Resources) helping the developing world with supplying reused ICT equipment to schools. Some of that equipment has Skolelinux installed[4]. as this newspaper article shows. They doing quality assurance of the computers in Norway before they are shipped to other countries. The French charity Emmaus also providing reused computers to public and private institutions. They are actively participating in the Skolelinux project from France[5].

2   Running cost

Running cost depends on various factors. The most noticeable are the amount for concurrent users, and how the software is distributed. Where the servers and services are placed has some influence on the operational cost. And what kind for service level agreement that's required. But first some background to understand the running cost of the ICT services that operates Skolelinux in all or many schools in their

Reactive problem control is to fix the problems when it appears. If the computer is infected by a virus one of the common strategies is to reinstall the system. Does the pupil want a program found on the Internet, it is just to install without asking if the program is relevant to for teaching purposes.

Advantage 1: Could be reasonable running cost if every computer has the same version of the operating system. For Windows it is necessary to have identical machines for efficient handling of image technologies.

Advantage 2: The schools could have stored ready-to-use PCs that could replace faulty machines.

Disadvantage: The consequence of different incidents demands a lot for work or gives long delays before it is fixed. E.g full disks.

Proactive problem control is to detect and fix the errors before the users experience it. One example on proactive problem control is to update disk image every night or weekly. When the pupils log into the system the day after, everything is like the school teachers want's it. The ICT operator get warnings about errors and such, and fix the problems before the users notice that some thing's are wrong. E.g the ICT operator gets a warning that a one of the mirrored disks is corrupted, and needs to be replaced.

Advantage 1: The system gets high uptime and stability given the right tools and skills to run such an operation. It gets more easy to handle more amount of computers

Disadvantage 1: Expects more skills running the solution. Gives more cost when establishing and operating the solution.

---

[2]InOut reseller of reused computers: http://www.inout.no/skolelinux/
[3]FAIR (Fair Allocation of Infotech Resoruces) http://www.fairinternational.org/
[4]Skolelinux from Norway to Eritrea in Norway's largest ICT transfer ever: http://europa.eu.int/idabc/en/document/3355/469
[5] http://schlossgul.org/wakka.php?wiki=PagePrincipale

Disadvantage 2: Proactive is more expensive than reactive problem control. What to choose depends on the consequences when the system is down. It is difficult to calculate the cost of lost work in the classroom if the tools don't work. Does the users want little downtime, it is necessary to invest in high uptime.

In general reactive problem control is not recommended if the goal is to have satisfied users. The only argument in favour for a reactive operation is (1) price or (2) lack of resources and/or competence. Reactive maintenance is not a thing that is chosen. It is something that is enforced on the schools.

Scalability is important for how to get the most of the investment. When the number of machines increases the cost could rise more than linear. A lot of things has to be taken care of when centralising the ICT operation. One of the most important factors when centralising is network capacity. But also where to place the services.

The Norwegian Educational Communications and Technology Agency gives this advice about placing services.

General recommendations to improve the client operation	Thin clients Lockdown of the clients Local servers	Remote operation Centralisation of certain services	Reginal or national servers Centralisation of all maintenance
The network capacity	Low bandwidth (IDSN)	Medium bandwidth (ADSL etc.)	High bandwidth (Fibre 1 Gbit/s)

The services that can be handled centrally independent on the bandwidth:

- Configuration management. E.g to have control over the configurations of machines, network, programs and services

- Software management. To have an overview and control on the use of programs and if the performance of programs and services

- Updates and security patches

- User administration. In the nordic countries the governments has got together to make a common LDAP schema for pupils. In Norway this is a part of the Federated Electroic Identety management[6]

- Licence administration

- Surveillance and measurements

Service level is also a part of the solution. Does the ICT service provide reactive problem management or proactive? What is expected when things go wrong. The ICT coordinator for the schools in Akershus City Council says that the don't want to pay for the extra cost for fail over. If a disk fails on a server when doing the exam, they would use the day to change the disk, and restore from backup. It is the same they do if one school has water leakage. That has happened. They fix it, and the next day they carry through the exam. The city of Oslo has a service level agreement with guaranteed uptime, and expected recover after machines crash or goes off-line. The guarantees is valid for approved workstation hardware, not for graphical Windows clients (Citrix) on reused computers.

The graph Server Client Ratio gives an overview on the amount of standard servers that are needed for different client solutions. The example is based on 5 schools with 320-450 pupils and 90 clients at each location. The graph is based on real life experiences when running different client solutions at many schools in Oslo, the main city of Norway.

It is mostly technical reasons for the different number of servers with the same amount of clients. In the City of Oslo they mainly have 2-8 Mbit/s broadband to the schools with their graphical terminals on Windows solution. They also have to support workstations to multimedia applications because of the limited performance on graphical clients when using multimedia. Then they has to place out two servers at every school. This is in

---

[6]FEIDE - Federated Electronic Identity: http://www.feide.no/index.en.html

Figure 1: Server Client Ratio

addition to the centralised placed servers to run the applications that is distributed with graphical terminals to the schools.

With use of graphical terminals the ICT service also get two architectures with running the software, maintenance and updates. The software runs on central servers and the ICT service also has to maintain software on local reused machines and workstations. This gives most of the explanation behind why the operational cost is notably higher with graphical terminals with Citrix or Free NX than other client technologies. That said does some municipalities support Free NX clients to pupils that have Windows or Linux at home as an additional service. It is easy to set up and the ICT staff don't need to maintain the client machines at home. If nothing works at home, they don't need to support it.

2.1 Operator cost in 2005

The tables that follow gives an overview of the positions and man-hours used to maintain and run the ICT system at the schools in our survey:

Municipalities City Councils		ICT operator centrally	ICT pedagogic coordinator	ICT contact at every school	Sum
Municipality Hurum (200 clients)	of	$\frac{1}{2}$ position		8 % position (2:40 h a week)	1,9 positions
Municipality Kongsvinger (450 clients)	of	$\frac{1}{2}$ position	$\frac{1}{2}$ position	10 % position (3:20h a week)	1,2 positions
Municipality Nittedal (506 clients)	of	$\frac{1}{2}$ position	$\frac{1}{2}$ position	6 % position (1-2h a week. Request for 4h a week)	1,6 positions (request for increasing ti to 2,1 position)
City of Oslo in 2008 (25 931 clients)		External ASP	2 positions	30 % position	*
Akershus City Council (6 600 clients)			80 % position	70-80 % position. Some also have apprentice	*

9

clients = client machines

With help of the three of the municipalities we got the overview of the operator cost in 2005:

Operator cost in 2005 with a Skolelinux network			
Art	**Nittedal**	**Hurum**	**Kongsvinger**
Number for clients	# 506	# 200	# 450
Central operator	25,773	25,773	25,773
ICT instructor	25,773		25,773
ICT contacts	29,454	35,345	53,946
External support	19,091	7,636	12,727
Training	28,000		25,454
Sum	128,596	68,954	144,122
Running operational cost/PC	**254 Eur**	**345 Eur**	**320 Eur**
Central operator cost/PC	**89 Eur**	**167 Eur**	**86 Eur**
Euro (100 EURO = 785.72 NOK)	7.86		

It is some important things to say about the persons that runs the ICT operation, and their different roles. The most important is the division of work done helping teachers using the ICT tools in education. That's often a totally different effort than build, operate and maintaining the ICT installations. So most of the municipalities has this arrangement with dividing the pedagogic effort and the technical. Some of the municipalities have a teacher with grate ICT skills with e.g certification in Red Hat and years of experience running Windows. Then they use that person as a project leader building up the operation.

In short the different roles are *ICT instructor* or a *coordinator*. This person works with the pedagogical aspects helping out headmasters and *ICT contacts* at the schools motivating teachers to use ICT tools in their teaching. ICT contacts helping out with technical issues as changing defect client machines, replace a broken keyboard or giving feedback about different request for software and services. The *Central Operator* is in general a person that works in the ICT service housed a central place in the municipalities.

2.2   Total running cost in 2005

This graph shows the total running cost in 2005 for three of the municipalities we have investigated.

The graph clearly shows that the biggest running cost for the work done by people is about 60-70% of the total running cost. The equipment cost annually around 30-40% of the whole operation.

2.3   Total operator cost in 2008

The City of Oslo has at least 10 schools that runs Skolelinux today. Some of them got an external service provider to operate the solution with competitive prices. When calculating the future cost of a enterprise

Figure 2: Total running cost 2005

Skolelinux solution this was taken into account. We also used the experiences serving 70.000 users accounts with e-mail, backup and single signon on 5 platform at The University of Oslo. Doing that we got a solution that was in accordance with the requirement from the City of Oslo.

The City also had a external service provider with an 5 year agreement to run and maintain the client machines and serves in the Schools. So the prices running todays Windows based system is known from the contracts with the educational department in Oslo. With this in mind we asked what the running operation would be for the other municipalities in 2008. Most of the municipalities had wide expansion plans already decided. The budgets was also in place. So here are the numbers:

Operator cost in 2008

Art	Nittedal Skolelinux	Hurum Skolelinux	Kongsvinger Skolelinux	City of Oslo Skolelinux	City of Oslo Windows
Number for clients	# 1,093	# 500	# 800	# 25,931	# 25,931
Central operator	25,773	25,773	25,773		
ICT instructor	25,773		25,773	51,545	51,545
ICT contacts	117,817	70,690	107,891	2,705,799	2,705,799
External support	7,636	7,636	12,727	3,326,885	6,283,409
Training	28,000		25,454	79,545	7,545
Sum	206,092	104,599	198,418	6,163,773	9,120,297
Running operational cost/PC	**189 Eur**	**209 Eur**	**248 Eur**	**238 Eur**	**352 Eur**
Central operator cost/PC	**31 Eur**	**67 Eur**	**48 Eur**	**130 Eur**	**244 Eur**
Euro (100 EURO = 785.72 NOK)	7.86				

Figure 3: Planned operational cost in 2008

One important issue is that the enterprise Skolelinux solution designed for Oslo will have requirements for service level that's higher than the other municipalities. It also has different client solution with Skolelinux diskless workstations. The latter is not on to on comparable to the Citrix graphical clients or workstation with Windows most of the schools uses in Oslo today. Most of the other municipalities are heavily users of Skolelinux thin clients with LTSP. The cost of running this in Oslo it is not much higher than diskless workstations, but it is some more expensive.

That said the graphs shows that the operational cost without hardware an network will decrease compared to the situation in 2005. The reason for this is mainly the scalability built in in the Skolelinux architecture. A central ICT operator is able to scape it is effort to handle an doubling of client machines without doubling the amount of work hours.

2.4 Market prices

In the summer 2005 we called some companies that provides professional support to schools with maintenance agreements. They act as standard application service provider serving customers running Windows systems or Skolelinux based solutions. We asked for the marked prices and how the prices varied depending on the numbers of supported clients. The reason application providers look to the number of clients is that this produces most of the work when supporting the ICT contact at the school.

Also the number of servers and the places where software is updated determine the prices as we can see from the prices concerning graphical terminals. The cost for the local ICT contact at every school ICT instructor is not calculated in. The cost for the network switches, electricity and broadband is not calculated in either. When doing this limitations the operational cost really shows the difference with different client solutions and some advantages running more clients at the same site.

2.5 Conclusions about costs

The calculations and analysis done by the City of Oslo shows that it is cheaper to run a ICT solution in the schools maintained from a central place with local ICT contact helping out with easy tasks. A enterprise solution with Skolelinux is considerable cheaper to operate than a Windows solution.

Experiences with centrally operated Skolelinux solutions in schools is that the operating cost is decreeing a little for every client machine when increasing the amount of PCs. That tells us that the solution is scalable when it comes to operational cost. The task helping users at every school is connected with concurrent users. This job is mainly done by the ICT contact. When increasing the amount of client machines from 50 to 100 the extra workload should not not be increased to more than a day a week when running a Skolelinux solution managed from a central ICT service.

Annually operator cost for each client + Hardware (over 5 years)

Figure 4: Annually operator cost for each client

When it comes to marked in the marked it shows that Lessdisk Workstations (lessdisks[7] or LTSP[8]) are 44% cheaper to operate than any other client solution. Windows and Skolelinux workstations comes on a second place when using reused computers and not calculate in the extra expenses with different machines and the software licences using software from Microsoft. To keep the operational cost with Windows low identical machines is recommended, and that's difficult over a period in 1-2 years because the manufacturer changes the hardware specifications all the time.

The thin client alternative with Skolelinux is cheaper than workstation in smaller installation or when reusing hardware as the main strategy at all the schools, as the municipalities shows us. The most costly alternative is graphical terminals with Windows (Citrix).

3   The risks

Before saying anything about technical risks, I'll focuse on the teachers role and competence.

The biggest risk when introducing software in the classroom is the human factor. An ICT service or a developer seldom know the requirements for use of software in the classroom. Technicians are often over-focuses on technical aspects. The teachers or principals are not specially known with use of software as a tool when teaching. Some teachers also use the computers as a reward for pupils that's fast in solving equations on paper in the math class.

Others don't really know where to start and they end up using computers to present traditional learning material with presentations made in OpenOffice.org or MS PowerPoint. Some ICT instructors have expressed they concern by this story:

We have placed out the "car" in the classroom. Now the teachers has to learn to drive it. Or else it is just a expensive toy, that is standing there with the screensaver on.

In Norway it is regulated by law that the employed and the union representative should be kept oriented about the systems that are used to plan and to do the job, also planned changes in such systems. Training should be provided to get to know the systems, and they should participate in developing the solutions.

There are big differences in the results in teaching the teachers even if it is used a considerable amount of resources on this. In the municipality in Nittedal the priorities to the headmaster is important. A centrally placed ICT instructor in half a position has difficulties reaching out to 100 teachers in 10 different schools. Therefore they need external resources. For the teachers to following up the courses, it has to be set aside time to that. The work with learning ICT has to be followed up. Learning in small groups with 3 to 4 teachers has been more successful than individual self study. The headmaster has to motivate the teachers. Nothing of this are dependent on operating system. Skolelinux is not more difficult to learn than Windows the ICT instructors says.

When it comes to the ICT operators few of them was known to Linux or Unix before they started. They taught

---

[7] The Lessdisks project: http://lessdisks.sourceforge.net/
[8] LTSP MueKow project: http://wiki.ltsp.org/twiki/bin/view/Ltsp/MueKow

them selves, used informal networks, and spread the knowledge when rolling out the solution at the schools. The local ICT contacts also lean from the ICT operator when visiting the schools doing maintenance. The cost of this is usually covered by the ordinary measures. Even if there are differences in background and experiences with the ICT operators running Skolelinux centrally, they have all got help on e-mail lists and tips over Internet.

3.1 Stability, security and upgrades

The municipalities report 100% uptime between 8 and 16 hours when there are pupils and teaching at the schools. It has been downtime at some of the schools because of some network plugs that was not properly connected to the network card. When it comes to handling viruses some of the municipalities has installed Clamav[9]. It has not been any virus attacks on Skolelinux. But they have identified some Windows worms that was aimed at MS Internet Explorer.

There are some activities to stop unwanted web-sites with the firewall. The are routines where the teachers reports unwanted web-sites, and the ICT operators submit this sites to the firewall.

When it comes to password handling it is important to have easy password for the pupils in the lower classes. Also it is almost an requirement that teachers can change password for pupils that has forgotten it. It is to much work sending a request about password to the central ICT operator to send this back to the teacher that then gives it to the pupil. So there are essential to have a delegated function that teachers could change pupils password without root access.

At last there are not wise to upgrade the installations in the schools semester. The municipalities most of the times does upgrades at the end of the semester, in the schools holidays. It is recommended to use the stable and same version of Skolelinux on all the machines. That's makes less worries.

3.2 Integration and user programs

When it comes to integration there are a lot of possibilities that are in use. One of the municipalities uses Skolelinux as the main server and K12LTSP as the LTSP solution. It is connected to the authentication service in Skolelinux LDAP with a standard Red Hat tool. Others use Skolelinux as a thin client server in a Windows 2000/2003 network integrated with Samba. A lot of schools connects Windows Workstations to the Skolelinux network.

A lot of questions are asked about the user programs. The municipalities that uses Skolelinux has no special concerns when it comes to most of the programs used in the classroom. Mostly because of the widely use of the web browser to gather information, or use of platform independent web applications.

But when it comes to OpenOffice.org there are some practical issues trying to open OpenDocument in MS Office at the home computer where one of the parents has got Microsoft programs from their job. They don't want to install OpenOffice.org. The schools and municipalities has 3-4 strategies handling this. Some municipalities just use OpenDocument as default and sending the pupils a CD home with OpenOffice.org.

Other places the teachers explains at the parent meetings that the real problem is that Microsoft does not really interoperate with the world because the pupils don't have problems with MS Office documents at the school. The problem is at home, so they should really install OpenOffice.org. Not all are able to explain this, so some of the schools just set MS Office as the default storage format when using OpenOffice.org at the school. With OpenOffice.org 2.0 that don't produces any problem the municipalities reports.

When it comes to web applications in Norway the most important vendors testing their application against different Linux distributions as Skolelinux and Red Hat. Also The Ministry of Government Administration and Reform requires that every governmental services on the web should be accessible with open standards[10]. This policy has broad political support both from the left, right and the centre in the political landscape[11]. From a commercial point of view there are now risky to not support open standard and say no to potential costumers

---

[9]Virus scanner Clamay: http://sourceforge.net/projects/clamav/

[10] Open Source in the Norwegian Government:
http://opensource.phpmagazine.net/2006/04/open_source_in_the_norwegian_g.html

[11] Norwegian Minister: Proprietary Formats No Longer Acceptable in Communication with Government: http://europa.eu.int/idabc/en/document/4403/469

in public sectors that stands for around 20% of all the acquisitions in Norway.

3.3   Translation

Norwegian is a little language in an international perspective with 4,6 million inhabitants and two official languages. In addition Sami is a co-official language of six municipalities and Finnish is used in one municipality. When most of the computer programs are almost instantly translated into the languages who many speaks as German, French or Russian, proprietary vendors don't see the need for translate their applications into the two official languages in Norway.

So what's done voluntarily has an impact. The Norwegian bokmål and nynorsk has good translation both in KDE and GNOME. KDE was translated to nynorsk in 2001. This inspired to translate OpenOffice.org to the two Norwegian languages. Then the Norwegian parliament decided in 2004 that every program used in education should be available in both the official Norwegian languages. Many says that this was possible because of the results done by the voluntaries. Since OpenOffice.org is translated it's used at many schools, also on Windows. And a lot of pupils copy it freely to use it at home.

There are initiatives that have professionalised the translating effort for some applications. e.g there is established a foundation for promoting free software office applications. They handles the translation of OpenOffice.org to Norwegian bokmål and nynorsk. The cost doing this is just a fraction of what the City Councils pays for Microsoft Office in the secondary schools. The average cost to translate and maintain the OpenOffice.org translation for two Norwegian languages cost 254 544 Euro annually. That's just a 4 to 5 times less than MS Office licences cost in most of the secondary schools in Norway, and then we are speaking of the special prices in the education.

Even if most of the free software in use at the schools are translated, some municipalities conclude that it is has some risks to be dependence on the voluntary effort. There has to be done work to maintain the translation in free software and the translation work and quality insurance of the translations should be paid for.

3.4   Licence revision

In 2004 the City Council in Akershus paid external consultants 31 818 Euro to count Microsoft licences at 31 schools. They also had the same cost internally to aid the counting done by the external firm. The municipalities that runs Windows tells they use 1-2 days a month to keep track of their licences in their schools, and 3-4 weeks when they do a licence revision. When we also know that a central ICT operator often has half a position to maintain 500 client machines at 9-11 schools, at least 2-3 weeks is used counting licences annually.

This practice has really upset some of the municipalities. The municipalities that are using free software have no extra cost concerning licence revision. As a marketing effort Microsoft says that schools with a MS School Agreement don't need to do licence revision when paying for all the machines, also them with Mac OS, Linux or FreeBSD. The companies school licences has been like this science 1998 a Microsoft spokesperson has told the press.

Paying Microsoft for using Linux, Mac or FreeBSD has upset a lot of people. Members of the Parliament has asked questions about the practice to the The Minister for Competition. The debate about this was high in the Norwegian computer magazines in December and January 2005/2006 after 12 out of 19 City Councils agreed on the Microsoft licence terms for schools without a public tender. The Minister wrote a letter to one municipality. She recommended to report the City Councils to The Norwegian Governmental Office for Complaints on Public Tenders. The Norwegian Competition Authority are for time being investigating Microsoft for their practice. The Competition Authority says that the schools in Create Britain could not sign this kind of agreement.

3.5   Maintaining free software

It is a lot of fear, uncertainty and doubt (FUD) spread about Skolelinux. One of the most important is that it is a voluntary community effort that will die when the founders get other things to concern about. Even if the solution is a part of Debian there are a lot of histories that weakens the perception of our effort. It is always questions about updates, maintenance, how to start, and training. E-mail lists with volunteers is just not good

enough. The schools will need professional support on daytime. Someone to keep accountable. That's not so much concerning the distribution, but more how to get help if something fails or break.

To ensure that people work to a common goal, that's difficult enough because all the free developers have their own motivation, and often no money, there is established a foundation that owns a professional service provider. They working actively to ensure a sustainable environment in cooperation with different companies and institutions. Also the international relations are of decisive importance as:

- Custom Debian Distributions with DebianEdu/Skolelinux branches of active developer communities in France, Germany and Greece. Also the cooperation with gnuLinEx in Spain (Extremadura), PSL-Brasil in Brasil and tuxLab in South Africa is of importance

- LTSP.org and Lessdisks are projects that support diskless workstations. The work that is done by the developers in (k)ubuntu, ltsp-team and Skolelinux really gives improved and easy to maintain client solution

- edubuntu project is a good thing running ahead improving the desktop experience. They also want to deliver a municipality wide server solution for schools in around 12-18 moths. Skolelinux and Edubuntu developers work together on different project to improve the offer to the schools

- Cooperation with resellers of reused computers. They sell solutions with making it really easy to acquire Skolelinux solutions for a whole school or a municipality

All this is done to fight of the impression that you need to be a Unix operator with sandals and long hair to maintain a large Skolelinux installation. The main purpose is to get it safe to use free software in a teaching environment.

4 Recommendations

In general free software gives a complete solution to the schools needs both pedagogically and technically. It is of grate importance to further educate the teachers in using to support an active learning process with ICT tools in the different subjects. The principals has to follow up on this because a lot of teachers has forgotten how to learn new things themselves. The teachers has to spend necessary time on this, and they has to work through the difficulties they will meet some part of the distance learning how to use ICT tools actively in the different subjects. The activity have nothing to do with the operating system in use and has to be done independently of what system that's in use.

The most cost efficient solution is diskless workstation where all the software is maintained on one server for whole the school. The operating cost approximately half the price to operate compared to thin clients or standard workstations. It will require extra effort to build a network with good enough quality. In the beginning the building of the network is probably the most expensive part. After this is built the operational cost consists of around 60-70% of the total cost of ownership. To increase the competence in building and maintain a ICT solution really pays of. It does not be a big price difference on operating the system using external application provider compared with municipality employees to run the technical part of the solution. We recommend an proactive maintenance strategy.

Avoid using graphical terminals as Free NX or Citrix on school wide installations. This kind of solutions is three times more expensive to operate than other solutions. Graphical terminals are nice as an unsupported alternative for pupils using the Skolelinux desktop at home. It is also used for teachers that uses an administrative applications from the municipalities administrative network. The networks are often divided to not mix restricted and personal information about citizens or pupils. Graphical terminals handles this nicely.

Generally there the suppliers has strong self interest when recommending client solutions to the schools. The functionally and the usability to the end user programs depends strongly on where the equipment is based concerning the bandwidth capacity to the schools. The main strategy should be to operating the systems centrally and place most of the equipment locally near the users. This will get the most efficient use of the bandwidth capacity and most functionality out for the clients.

When building and deploying the ICT solution in the school there must be made a realistic budget. In Norway there is different standards for purchasing technical solution in general and special recommendations made for ICT installations in schools. This is not rocket science and it is relatively easy to get professional support on Skolelinux in Norway. Other countries has also agencies that gives good recommendations for purchasing and rolling out ICT solutions in schools.

Decides if the pupil should save documents as OpenDocument or MS Word. When saving in OpenDocument the teachers has to be explained how to handle the relation to the home, and how it could be solved. Some municipalities support Free NX to the pupils at their home to families that have broadband. Others promote use of OpenOffice.org and gives all the pupils a live CD (Knoppix) with Windows and Linux versions of different software. Then the OpenDocument is not a big issue.