Diskless Client Information Technology: Achieving energy and cost savings in Saanich School District

Project Overview

Computers in the public school system are used for both administrative functions and educational purposes. Schools typically acquire their classroom computers through donation, resulting in second- or third-hand computer systems that are nearing the end of their life span. Such computers require more maintenance and use more energy than new energy-efficient systems, elevating their cost to operate. These personal computers (PCs) also require software to be installed and continually patched on each unit, leading to high licensing and staff costs. The end result is a high educational price for a sub-par computing system.

Saanich School District (No. 63) is in the process of upgrading its computing technology across the entire district. The district employs 788 people and serves 7,452 students across 18 schools. There are approximately 2,500 computers in operation. All elementary and middle schools have had their computer technology upgraded (completed summer 2011); secondary schools will be upgraded in coming months (by summer 2012).

The project to upgrade PCs to new diskless client technology is motivated by several factors: reducing costs, reducing energy consumption, providing staff with development opportunities, and enabling students to learn relevant technology-based skills to keep pace with twenty-first century learning. Key to this project's success is the technology itself; a diskless client model is more efficient. This technology is expected to reduce IT energy consumption across the school district by 70%, thereby reducing the district's total energy consumption by 10%. This will bring the district forward by two years toward its 2020 energy consumption goals that aim for a 50% reduction in energy use over 2007 levels.[1] Costs associated with computer technology will be reduced by almost 70% over ten years.

Project Background and Context

The diskless client project is supported at several levels in the district: policy direction, senior stakeholders, and key staff.

[1] "Policy 1370 Environmental Learning & Sustainability," Strategic Energy Management Plan, School District No. 63 (Saanich), 2011, p10.

Saanich's *(Draft) Strategic Directions 2012-2016* and its *District Technology Plan 2010-2012* are two documents not typically developed by most school districts, demonstrating Saanich's leadership in these areas. *Strategic Directions* identifies a more sustainable future in which the district is "a leading contributor to a vibrant sustainable community" and in its operations is committed to: "reducing energy by 25% and greenhouse gas levels by 15% by 2016," and "supporting the full implementation of the district technology plan."[2] Section 1.5 of the *Technology Plan* discusses a shift to "green computing": "As part of our overall strategy for technology infrastructure the district will incorporate measures to minimize power consumption for desktop and server computers" and will upgrade the district's computers to diskless clients and LCD monitors to lower its "IT carbon footprint."[3] Additional policy documents also offer support for this project and the objectives of increasing energy efficiency and energy sustainability and also reducing waste: *Environmental Learning and Sustainability* (No: 1370); *Purchasing* (No: 2500); *Use of Technology and Information Systems* (No: 3130).[4]

The district's senior stakeholders—the Superintendent, the Secretary-Treasurer, and the Board of Education—have recognized the value of the project and its fit with the district's strategic direction. The district is unique for its approach to information technology (IT) at the departmental level; the IT department is situated equally within the school district's education and business units, and it has its own director who brings leadership and decision-making authority to the department. The idea to update the district's computer technology to the diskless client model was developed by Saanich's Director of Information Technology, and the project has been further supported by the district's Energy Manager—a staff position funded by BC Hydro.

A New Solution for School IT: Diskless Client Model

The PC classroom model has a high overall cost of ownership. Software licensing, support, and upgrades are high costs with PCs; a license must be purchased for each computer and the application and upgrades installed on each unit, one at a time, by IT staff. Also high are the costs associated with virus protection, service packs and patches, hardware, and support staff needed to maintain each unit. The hardware donated to schools typically has only 1-4 years of life, requiring costly replacement when it dies and generating e-waste. Beyond its regular operating hours, each PC that is not turned off by users or support staff at the end of each day will continue to use energy and drive up costs overnight and on weekends.

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[2] *Strategic Directions 2012-2016 (Draft)*, School District No. 63 (Saanich), 2011, p 29-30.
[3] *District Technology Plan 2010-2012,* School District No. 63 (Saanich), 2010, p 11.
[4] http://www.sd63.bc.ca/ourboard/board-policies

In contrast, the costs associated with the clients used in a diskless client model are relatively low. Diskless clients utilize operating systems and software applications that can be accessed from a nearby server or online (cloud computing), rather than stored on each computer's hard drive. Applications stored on a server can be updated for use by all connected computers at once at this central point of control, rather than at every computer station in a school. Many of these applications have the added benefit of being open source (available to anyone without cost). Web-based cloud computing and open source software significantly reduce the costs of software purchase and licensing and the cost of staff time to load and maintain software.

The relevance of the PC is changing as more software applications become web-based. However, not all software applications currently used by the district have open-source equivalents or the capability of being hosted on the Linux server used with clients in the diskless client model. Consequently, the district has retained some PCs with their Windows operating systems and Windows-based applications in order to meet curricular needs. The ratio of diskless clients to PCs now in operation in the district's schools is 9:1 for elementary schools, 10:1 for middle schools, and 6:1 for secondary schools; using both systems together creates a "hybrid" diskless client model.[5] The secondary school ratio is lower due to the current use of Windows-based computers in teaching labs; these PCs will be phased out in the next one to two years once teachers have been able to integrate new technologies into the curriculum.

The trend toward web-based computing is seen to provide educational benefits in addition to economic and environmental benefits. The ability of the diskless client model to access applications online allows for the easy customization of available software to support learning outcomes. Changing to different online, open source applications is quick and without cost, and adapting to new applications is a valuable skill for students to learn.[6]

Diskless clients provide "the best possible compromise for large scale computing environments where TCO [total cost of ownership], energy reduction, sustainability and functionality are prerequisites."[7]

[5] Ferrie, Gregg. *The Benefits of Managed Diskless Client Technologies in an Educational Environment*, Athbasca University, Alberta, 2011, p 14; also personal communication.
[6] For further discussion of technology in education, see *District Technology Plan 2010-2012.*
[7] Ferrie, p 42.

Comparison of PC, Thin Client, and Diskless Client Systems[8]		
PC	**Thin Client**	**Diskless Client**
CPU—fast processor	CPU—slow processor	Processing shared between server and client (distributed) using Local Apps – distributed processing[9]
Hard drive	No hard drive	No local hard drive
Local operating system (Windows)	Operating system on server (Linux/proprietary)	Server-based Open Source Operating System (Linux/Ubuntu)
Local applications	No local applications	Local Apps – distributed processing
Good sound and graphics ability	Poor sound and graphics ability	Good sound and graphics ability
RAM—2Gb+	RAM—128Mb-512Mb	RAM—512Mb-2Gb
High availability	Low availability	Low availability
High cost—$550-$1000+	Medium cost—$300-$500	Low cost—$200-$300
Server not required	Server required	Server required
clients on a server: n/a	20-30 clients on a server	Up to 300+ clients on a server (depending on the capability of the server)
Life expectancy of hardware: 1-4 years (donated)	Life expectancy of hardware: 6-8 years (useful life is less due to hardware limitations)	Life expectancy of hardware: 6-8 years
High support costs (PC-based)	Low support costs (centralized)	Low support costs (centralized)
Not energy efficient	Highly energy efficient	Energy efficient
High Watt power supply—90-300 Watts	Low Watt power supply—3-20 Watts	Low-mid Watt power supply—25-60 Watts

[8] Adapted from Ferrie, p53, and "Dramatic Energy Reduction Through the Use of Diskless Clients," Gregg Ferrie and Jay Armstrong, Saanich Schools SD63.
[9] https://wiki.ubuntu.com/Ltsp-Local-Apps

Project Details

Saanich School District's Director of IT and its Energy Manager have led the technology upgrade project from idea through to implementation. The many stages of planning for this project have included consultation, risk analysis, energy optimization, budget planning, consideration of staffing requirements, and development of an implementation schedule. Critical to making the project happen has been the analysis of energy and cost savings that demonstrates the feasibility and benefits of the project.

To determine the potential for energy and cost savings of upgrading district computer technology from PCs to diskless clients, a baseline was first established. The number of existing PC computers was counted and the demand was measured with a Watt counter (Watts Up Pro) for the various PC configurations (hardware models) used in district offices and classrooms. To measure the demand for diskless clients, IT staff attached the Watt counter to a diskless client and approximated the operation of the client over the course of a week including the weekend.

Because PCs must each be shut off individually, it is common for units to be left on overnight and over the weekend; time in active and idle modes was determined through qualitative research involving BC Hydro PowerSmart Engineering, other school districts, and custodial staff. Calculating the baseline for energy use and cost utilized the wattage data collected from the various configurations, the number of hours that the PCs were active/idle/on standby (24/7), and the resultant yearly energy consumption. The yearly estimated consumption was then validated against past utility bills. A similar methodology was used to determine the projected energy consumption for diskless clients, assuming their use across the district instead of PCs. The baseline for PCs and the projection for diskless clients were then compared to determine the potential reduction in energy use and the estimated cost savings.

Diskless clients typically run on 35 W when active, dropping to 28 W when idle and just 2 W when on standby. Compared to PCs, which typically run on 105-120 W when active and 84-96 W when idle[10] (80% power), this represents a significant energy and cost savings.[11] The server can be used to boot up every computer at once (in just 20-30 seconds) and to power down at once all the diskless clients across the school.

[10] PCs run on 8W when on standby, however many PCs in schools, the public sector, and businesses will never enter standby mode due to overnight maintenance needs.
[11] Monitors are not included in these measurements.

For the first stage of the diskless client project[12] consisting of technology upgrades to elementary and middle schools (1,315 computers), the baseline for PCs showed a baseline demand of 157 kW, and baseline consumption of 611,497 kWh/yr (465 kWh/yr per unit). The projection for diskless clients showed a demand of 46 kW, and consumption of 87,297 kWh/yr (66 kWh/yr per unit). The reduction in demand achieved by using diskless clients instead of PCs is 111 kW, resulting in energy savings of 524,200 kWh/yr. With additional projected energy savings of 176,732 kWh/yr from new LCD monitors, the projected cost savings on energy is approximately $40,000 per year.[13] Utility bills received after project implementation show that the realized reduction of 637,276 kWh/yr was within 10% of estimates.

For the second stage of the project[14] consisting of upgrades to secondary schools (791 computers), the baseline for PCs showed a baseline demand of 95 kW, and baseline consumption of 368,385 kWh/yr (466 kWh/yr per unit). The projection for diskless clients showed a demand of 28 kW, and consumption of 48,583 kWh/yr (61 kWh/yr per unit). This stage of the project has not yet been implemented, but the energy savings expected from its implementation is approximately 319,802 kWh/y and the cost savings is estimated at $23,000 per year.

Lower capital costs, lower licensing costs, and the slower rate of replacement for diskless client technology provide additional savings. Combined with energy savings, the expected reduction in overall costs achieved through an upgrade to diskless client technology is significant (figure 1). Further savings maybe garnered by upgrading diskless client infrastructure with active power management.

[12] See Appendix 1, provided by Saanich School District.
[13] The rate for electricity purchased from a utility company is assumed to be $0.06 per kWh.
[14] See Appendix 2, provided by Saanich School District.

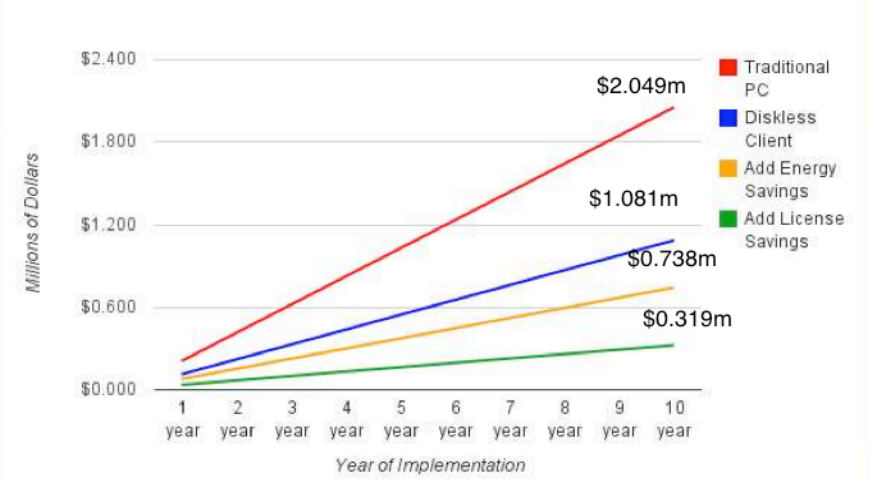

Figure 1: Costs for PCs versus diskless clients in Saanich School District. Accumulative comparison shows the reduction in capital costs from PCs to diskless clients, with additional cost reductions for energy savings and changes from commercial licenses to open source software licenses. (Source: "Dramatic Energy Reduction Through the Use of Diskless Clients," Gregg Ferrie and Jay Armstrong, Saanich Schools SD63.)

Benefits and Opportunities

In addition to the energy and cost savings described above, the project is experiencing a number of other benefits and opportunities.

Reductions in waste and GHG emissions
Processing is done on the server of a diskless client system, resulting in a longer lifespan of the client hardware (6-8 years) and less e-waste produced over time.

The GHG emission reductions achieved with energy-efficient diskless clients are expected to equal approximately 24 tonnes of GHG equivalents per year for all schools in the district. The drastic reduction in overnight energy use due to the ability of the server to power down all clients in a single sweep plays a significant role in these emissions reductions. Furthermore, as overnight energy supply is often not from the cleaner sources supplied during the day,[15] the actual emission reductions are likely much larger than can be easily tracked.

Staff development
The move away from maintenance-heavy PCs is allowing for IT staff to develop their skills in twenty-first century computing and orient toward a more pro-active approach to the district's IT and energy conservation opportunities. The achievements in both technology advancement and energy reduction are anticipated to draw highly trained technical staff to the district.

[15] http://web.uvic.ca/~kooten/documents/BCgeneratingSystem.pdf

Exposure and reputation
Saanich School District is experiencing an increase in exposure from the early success of the diskless client project. The Director of Information Technology sits on a number of committees, which furthers the understanding of this project across the region and province. BC Hydro has brought additional exposure to the district through presentations and conference meetings. As the first of its kind, the diskless client technology upgrade is a pilot project that is expected to contribute learnings applicable to a wide variety of users and situations.

Shared service model
Saanich School District has developed the expertise to plan and implement large diskless client upgrade projects, and it recognizes the opportunity to share these expertise with others. One possible way of doing this would be to establish a not-for-profit foundation where such expertise can be centralized to assist a broad range of users and organizations to transition to diskless client technology. This foundation could also potentially act as an incubator to test the technology in new situations, or to test technology improvements or new technology.

Provincial impact
The impact that diskless client technology could have across the province is enormous, even if the technology were to be limited to only the school districts. The implementation of this technology in all of Saanich's public schools is conservatively expected to result in a savings of 900,000 kWh/yr (0.9 GWh/yr). With the remainder of the province's school districts estimated at 82 times the size of Saanich School District No. 63, the potential exists to achieve an energy savings of 74 million kWh/yr (74 GWh/yr) if all schools in BC were to switch to diskless client technology. In comparison, this potential energy savings is roughly equal to the total savings currently being achieved through BC Hydro's PowerSmart program. The current cost of 74 GWh is approximately $5.2 million.[16]

Challenges

Capital costs
Despite the expected cost savings from technology upgrades, the initial costs required for such a project can make it challenging to implement. School districts have two types of budgets—operating budgets and capital budgets. Operating budgets are used to fund human resources and recurring costs such as maintenance. Capital budgets are used to fund upgrades and new projects—items that are one-time costs, such as the major upgrade of new computer

[16] Data and calculations provided by Jay Armstrong, Energy Manager, Saanich School District. Calculations are intended to illustrate approximate impact only, and are not inclusive of all possible factors that could increase or reduce the amount of energy savings and costs.

technology. The challenge with capital budgets is that school districts must raise this money themselves (capital budgets are not supported by the Province). Saanich School District overcame this challenge by selling some district property to raise project funds; other school districts may need to find other ways to raise funds.

Staffing
Upgrading from PCs to diskless clients requires an upgrading of knowledge and skills. IT staff must learn how to operate and maintain the new hardware and software. Administrators and teachers must learn how to use and teach these new ways of computing. The shift from using commercial software installed on each unit to using an operating system installed on the server and open-source (non-commercial) software accessed online requires time and opportunities to learn and to develop curricula.

Computing and teaching cultures
Kindergarten to Grade 12 education in BC has long focused on teaching specific software applications. These applications have been purchased and installed on classroom PCs, and lesson plans have been developed by teachers to teach these applications. The shift to diskless client technology that will access open-source applications online will require teachers to learn different applications, but more importantly will mark a cultural shift from the teaching of software to the teaching of skills. Applications will come and go, but the ability to adapt to new applications and new ways of working that are enabled by new technology will be a fundamental skill for students and teachers alike.

System design and knowledge transfer
Documentation and modularity of the design of the system are paramount. The people that design and maintain the system have crucial knowledge, which must carry over to new people as attrition occurs.

Next Steps

Saanich School District is still implementing this project and working through challenges as they arise. The district recognizes a number of necessary next steps that the project will address as it continues to move forward.

Teacher support
To support teachers to successfully transition to the diskless client technology, the district has hired a full-time teacher dedicated to assisting other teachers and users of the new computing model. Teachers have also shown interest in receiving more training beyond just the basics. This new position is tasked with listening to users' needs and continually improving this new model.

Servers
The diskless client technology has different requirements than the PCs for servers and cooling units. These requirements are still being assessed for optimal efficiency. The energy consumption of servers and cooling units has not been factored into the energy and cost calculations discussed above, but diskless client systems require less heating and cooling.

Most of Saanich School District's desktop-based applications have been shifted to the school client server, a district server, or servers hosting web-based applications on the internet. The shift to using external servers is a current trend that exists beyond the district. Servers run by larger, experienced organizations (Amazon, Google, etc.) are routinely optimized—more so than servers in the district. It is unclear what the energy implications of this shift are.

Energy management opportunities
As IT staff become more proficient managing the new technology there will be more opportunities to increase energy savings. Additional features such as manual start-up and active power management (tracking computer use and shutting down inactive clients throughout the day) may be added in time to reduce energy consumption and associated costs.

As portable technology becomes ever more pervasive, the district must embrace and guide the technologies that will be allowed and supported within schools. For example, every student bringing their own laptop/tablet/smart phone and charging it at school would drive up the district's energy costs considerably. However, selective technologies such as e-ink tablets may only increase energy use slightly while bringing vast educational benefits and cost savings to the district.

Tracking the total cost of ownership
Setting up a database to track the technology inventory and performance data would assist the district to determine its direction regarding technology decisions such as purchasing and disposal. The database could track lifecycle data such as energy consumption, GHG emissions, operating time, energy rates and cost, maintenance costs, disposal costs, and more.