UBC Social, Ecological Economic Development Studies (SEEDS) Student Reports

An Investigation into Sustainable Computer Hardware Project Report

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November 2009

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ABSTRACT

In this report, a recommendation was provided on purchasing *sustainable* computer hardware for the new Student Union Building, with social, economic, and environmental aspects in mind. Research was performed both on current user model and current purchasing practices employed at the AMS. Comparisons were drawn between three types of solutions: desktop PC's, which are currently used, notebooks, and small-form factors (nettops). Each option was evaluated on matters of: performance, power consumption, lifetime, cost, ease of maintenance, and ease of disposal. A triple bottom-line conclusion was reached suggesting that the current model should be pursued, with minor suggestions.

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LIST OF ABBREVIATIONS

AMS - Alma Mater Society

CRT - Cathode Ray Tube

IT - Information Technology

LCD - Liquid Crystal Display

PC - Personal Computer

RAM - Random Access Memory

RoHS - Restriction of Hazardous Substances

SSC - Student Service Centre

SUB - Student Union Building

UBC - University of British Columbia

1.0 Introduction

In view of the forthcoming design and construction of the new Student Union Building on UBC campus, the Alma Mater Society (AMS) hopes to avail itself of this opportunity to lead the way in sustainable practises and implement all of its services and functions in a socially, economically, and environmentally conscious way. One of these functions is to administer the finances and policies of student clubs and the student population at large through different levels of bureaucracy. As in any well-functioning offices, AMS administrators require reliable computational resources. We hold as a prerequisite to any proposed system that it equip each administrator with a personal computer able to perform tasks such as financial accounting and Internet browsing.

In this report, we examine the issue of Sustainable Computer Hardware for usage in the new SUB. The scope of our study will encompass different methods of providing computational resources to future SUB users, and we aim to provide a recommendation on the most sustainable approach based on this analysis. Our study is divided as follows. We will begin by defining the users whom we expect will make use of the computational resources in the SUB, and what functions they should serve on that basis. We will then evaluate different methods of providing these services and compare them on the basis of performance, size, power consumption, features, lifetime, and cost. Separately, we will address the issue of maintaining and repairing such systems, and which favour sustainability in this respect. We will conclude with a look at the problem of disposal, also known as e-waste, and will recommend certain avenues.

2.0 Usage

Before committing to any of the different possible options for sustainable computer hardware, an understanding of the typical use cases for such technologies must be considered. In this section, we will investigate the several use cases for different individuals who frequent the SUB. We will first examine the use of computer hardware from a UBC student's perspective. We will then analyze the role of computer hardware for AMS administrative staff, which represents by far the lagest portion of AMS-associated computer usage in the SUB.

2.1 Analysis of Users

2.1.1 Student

On any given school day during the week, the SUB sees upwards of hundreds of students spending time there. As such, the SUB is basically a hub of services available to students and faculty (e.g.: a place to eat, AMS club functions, etc...). Of the numerous services available, the SUB provides students with several banks of personal computers to use free of charge. Although the computers may not be equipped with special software and tools specific to individual needs, the computers offer a general platform for basic operations. Examples of such operations can include checking email, reading news articles, social networking, and student-focused tasks using any of UBC's available web tools (e.g.: SSC, Vista, WebCT)

2.1.2 AMS Staff

On the other end of the spectrum, computer hardware in the SUB plays quite a different, and significant role for AMS staff. As with any comparable present-day organization providing the breadth of services the AMS and SUB offer, a robust IT infrastructure must be set in place to foster efficient workflow and communication. The scope of use cases typical to AMS staff spans many uses. A few examples of such uses include "administration, financial transaction(s), (and) payroll" (Hong-Lok Li, personal communication, November 16, 2009). Of course, the use cases of AMS staff are not limited to the above examples. In general, such operations typically require a computer capable of running currently available productivity suites and a solid web browsing experience.

3.0 Acquisition

In this section, we will consider the factors involved in purchasing computer hardware in a sustainable way. We will first present two standards that computer products should absolutely meet and relate these to social, economic, and environmental considerations. We will then delve into a comparison between different types of solutions for the main components of a computer: tower and monitor.

It should be noted that the transiting student user, as described in the previous section, is a disappearing model, being almost completely replaced with using personal notebooks or handheld devices. In view of these consumer habit changes, it appears the costs of purchasing, maintaining and powering a bank of free-usage computers will soon outweigh the social cost of removing the option altogether. We will thus exclusively assume the following user model in this section: an AMS administrator with a need for a reliable and durable personal computing system.

3.1 Standards

3.1.1 Restriction of Hazardous Substances (RoHS)

RoHS is a European Union directive on the restriction of certain substances in the electrical and electronics manufacturing industry. "The substances banned under RoHS are lead (Pb), mercury (Hg), cadmium (Cd), hexavalent chromium (CrVI), polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE)" (Information Guide to RoHS compliance, 2009). Effective July 2006, all products sold in the EU have to be RoHS compliant. This directive has forced certain manufacturers to standardize their products sold worldwide to meet these standards. Many countries besides the EU have similar policies in the works.

RoHS compliance ensures a healthier working environment for employees in the electrical and electronics manufacturing industry, which could extend to millions worldwide. RoHS thus alleviates many of the health care and social costs associated with contraction of diseases and infections resulting from prolonged contact with hazardous substances. It also strongly affects individuals at the receiving end of electronics waste disposal, where health concerns due to contact with these substances is extreme.

The economic impact of this directive has only had effects at the manufacturing level, where certain fabrication procedures and equipments had to be replaced. The cost of individual products has seen little or no change resulting from this directive. We thus place RoHS compliance as one of the top criteria in determining the sustainability of a product. Some manufacturers that have adopted this standard across all their product line include, but are not limited to, HP, Dell, and Sony.

3.1.2 Energy Star Ratings

"If all computers sold in the United States meet the ENERGY STAR requirements, the savings in energy costs will grow to more than $2 billion each year and greenhouse gas emissions will be reduced by the equivalent of greenhouse gas emissions from nearly 3 million vehicles" (Energy Star, 2009).

Power consumption is an undeniable factor in determining the sustainability of a product. The "Energy Star" rating is a US governmental label that helps consumers make energy conscious decisions when purchasing electrical appliances and electronics. It is applied to a wide range of products, and deals with efficiency standards and expected annual energy consumption.

In the case of computer towers and monitors, the Energy Star ratings deal with efficiency of power supply and absolute power consumptions. They are an excellent indicator for purchasing more sustainable options. Power efficiency is cost-saving and lower power consumption reduces carbon footprint. The Energy Star Rating is a greatly recommended asset for any computer hardware purchases.

3.2 Solutions

3.2.1 Comparison

Types of solutions depend on user model. In the case of an AMS administrator, a personal computer with significant storage space, standard performance characteristics, and a medium or large monitor seems to be an appropriate package. Here we are faced with several possibilities: notebooks, personal desktop PCs, small-form factor (nettops). Based on current and envisioned AMS purchasing practises, we will only consider the acquisition of new computer systems (Li, 2009).

We consider the personal desktop PC to be the ubiquitous tower with monitor, nettops to be reduced-size packages holding motherboard and communication ports, and notebooks to be synonymous with laptops.

The following chart (Figure 1) outlines several characteristics for each system:

- Performance is the ability of the machine to conduct operations as required by the user (Microsoft Office, Internet Browsing) in a smooth and timely fashion, so as not to waste time.
- Weight & Size are considered for their transportation impact. Obviously the larger and heavier the item, the more energy is spent shipping it to UBC, or sending it away for repairs. Transportation has a large carbon footprint in the life cycle of a machine.
- Power Consumption is the machine's direct rate of energy use, and of course, is an important element in determining its sustainability
- Features are the machine's versatility with respect to user demand. Machines that demand less work (and frustration) from the user are socially more viable
- Lifetime is the expected operational time of the machine from purchase to disposal. This factor seriously affects its sustainability since smaller lifetime means raw materials, manufacturing, and shipping, are required at a higher frequency.
- Cost is the initial price tag of the product

	 Notebooks	 Desktops	 Nettops
Performance	-Will run most computations without trouble -Medium amount of storage	-Will run any computation without trouble -Large amount of storage	-Limited by its reduced processor power -Medium amount of storage
Weight & Size	Small 2kg-5kg	Large (incl. monitor) 10-20kg	Medium (incl. monitor) 10-15kg
Power Consumption	40-70W	150-250W for tower 30-70W for monitor (can be LCD or CRT)	10-20W for tower 30-70W for monitor (can be LCD or CRT)
Features	USB ports, CD/DVD drives are at hand's reach	USB ports, CD/DVD drivers are at hand's reach	no drive capacities limited number of USB ports
Lifetime	3-4 years	5-6 years	n/a
Cost	$500-$2,000	$500-$2,000	$200-$500

Figure 1 Solutions comparison chart

Based on the criteria outlined in the Figure 1, our provisional recommendation would lean towards Notebook purchases for all AMS administrators. They provide by far the most energy conscious decision, while preserving much of the versatility and performance of a desktop PC. The lower cost of Nettops are far outweighed by the inconveniences posed by their limited performance and versatility, both of which are social costs.

3.2.2 LCD vs CRT

In the case of desktop computers, the preferable choice between LCD screens and CRT monitors is an easy one. For a comparable size, LCD screens will consume on average about half the power of a CRT monitor. CRT monitors also tend to have health hazards: some contain leaded glass which is a concern at the disposal stage. Additionally, the flicker effect of CRT monitors can contribute to user eye-strain. LCD are also lighter and less voluminous, thus reducing their transportation carbon footprint in comparison to CRT monitors.

While LCD screens tend to be more expensive initially, the extra cost is made up by pure power consumption considerations. Let us perform a small calculation. Assuming the cost of an LCD screen consuming 30W is ~$150 and the cost of a CRT monitor consuming 70W is ~$80, how long would it take for the two options to be economically identical (assuming no inflation, and ignoring present value calculations)? At ~10 cents/kWh (BC Hydro, 2009), and for a usage of ~12 hours/day and 300 days/year, it would take ~4 years. This is smaller than the lifetime of an LCD screen, and so a viable economic option.

LCD screens are the better option economically, environmentally and socially (health).

4.0 Maintenance

In accordance to IT deployments in organizations not unlike the AMS, maintenance plays a key part in the overall efficiency of the system. Tasks such as repairing and replacing of broken and defective parts all play a role in contributing to maintenance of an IT infrastructure. In this section we analyze the feasibility of maintenance with respect to the three options chosen for sustainable computing hardware.

4.1 Analysis of Solutions

4.1.1 Notebooks

Of the three options chosen for consideration, notebooks prove to be the most difficult to maintain. Due to the comparatively closed nature of notebook computer hardware design, replacement of defective or broken components can be resource intensive as a result several factors:

- Notebooks are meant to be mobile. As such, staff would have the option of carrying the notebook computer off-site for work at home. Therefore, repairs done to them are at the mercy of having the user personally bring the machine in for repair as opposed to having IT staff conduct repairs on the machine regardless of user presence.
- More severe problems involve sending the entire machine out to the manufacturer for repair. This can only be remedied with a costly replacement program in which the user is given either a loaner machine, or an entirely new replacement machine. Without such a replacement program, this results in a staff member without a work computer.
- Notebook components tend to be more expensive than their desktop counterparts, and require more time and precision to replace. Some of these components can only be replaced by the manufacturer, since access to integral components in a notebook voids the manufacturer warranty.

4.1.2 Desktops

Desktop computers represent a solution that is currently in use by the AMS. From a maintenance standpoint, desktops prove to be superior to the other two options due to the total modularity of its hardware components. As such, desktop systems provide a solution that is more or less opposite to a notebook computer deployment.

- Desktop components are inexpensive, easy to replace, and seldom void manufacturer warranty should repair work need to be conducted.
- Repairs can be done regardless of user presence, since the computer hardware itself is bound to the desk.

4.1.3 Nettops

Low power, small form factor machines otherwise identified as "Nettops" represent a proposition that is relatively new to the computer hardware industry. These lightweight computers often share the same internal components as notebooks, but retain some of the modularity that desktop systems offer.

- Changing some components like RAM modules may still void warranty, depending on the manufacturer.

5.0 Disposal

E-waste, short for Electronic waste, is a growing issue among waste management topics. E-waste is harmful to the environment because of its composition which may include arsenic, cadmium, lead, mercury and nickel. Landfills are not an option because of the possibility of these materials leaching into local soil and water. In addition to the local environmental problems, another aspect of proper e-waste disposal is to ensure that it does not get exported overseas. This is a common, and illegal, practice in North America and most of it ends up in third world countries where the cost to recycle e-waste is cheaper, but at the expense of the health and environment of the local population due to improper disposal and recycling techniques using manual labor and inadequate safety measures.

This section will evaluate and recommend a disposal method for all three options previously considered. It will stand as a separate recommendation from others presented in this report since all three purchase options are equivalent with respect to disposal (fabrication materials being the same).

5.1 BC Electronics Product Stewardship Plan

Section 4 of The Recycling Regulation provides the legal means for producers to submit stewardship plans for a specific product category. The Electronics Stewardship Association of BC (ESABC) and the Western Canada Computer Industry Association (WCCIA) presented plans that were both approved by the BC Ministry of Environment in December 2006 and October 2007, respectively. If an organization wishes to collect, process and recycle e-waste in BC, then they must adhere to the approved stewardship plans.

5.2 UBC Waste Management

5.2.1 Description of E-waste Service

Currently, the AMS contacts a non-profit organization dedicated to reducing electronic waste through the re-use and recycling of unwanted computer hardware, however, instead of having to manage this on their own, they may instead take advantage of the UBC Waste Management e-waste service on campus for proper disposal. The AMS has used them before for such services, but they re-evaluate their decision when it is again time to dispose of e-waste.

UBC Waste Management collects e-waste from UBC departments defined under the Stewardship Program approved items. Stewardship approved items are accepted free of charge and include the following:

- Desktop and laptop computers
- Monitors (LCD and CRT)
- Televisions
- Computer Peripherals (mice, keyboards, etc.)
- Printers and Fax Machines

Non-stewardship approved items may be subject to recycling fees. These include:

- Microwaves
- Stereo Systems
- Video Cameras
- DVD/CD players
- Large Printers/scanners (photocopiers)
- Handheld Electronics

After collection, UBC waste management turns over the items to one of three organizations:

5.2.2 Freegeek Vancouver

Free Geek's mission statement: Free Geek is a nonprofit community organization that reduces the environmental impact of waste electronics by reusing and recycling donated technology. Through community engagement we provide education, job skills training, Internet access and free or low cost computers to the public.

Free geek donates or resells computers collected that are in working condition for a very modest price and also have a "earn-a-computer" program where volunteers can receive a free computer. They also have a computer "thrift-store" where customers looking for an old hard to find part can browse through and purchase one. An entire list of the items that they accept can be found on their website.

5.2.3 Encorp Pacific

Encorp Pacific (Canada) is a federally incorporated, not-for-profit, product stewardship corporation with beverage container management as their core business. In 2007 Encorp won a contract from the Electronic Stewardship Association of BC to manage a recovery program for the end-of-life electronics covered by BC legislation. Encorp collects the e-waste that UBC produces that falls within the Stewardship Program's approved list of items.

5.2.4 E-cycle Solutions

eCycle Solutions is national electronics recycler and an approved processor under all existing provincial stewardship programs. Of the e-waste items that do not fall under the Stewardship Program's approved list of items, E-cycle can accept and process these items for a fee.

5.3 Recommendation

For the three different desktop computing options being considered for the SUB, the BC Electronics Product Stewardship Plan includes free recycling for all. Each of them are accepted and are on the approved list so each option is viable. Since this is the case, the recommendation made in this section suggests that the AMS should consistently use UBC Waste Management's e-waste collection service instead of contacting multiple other external sources. UBC waste management has the resources to collect, are within close proximity, and accept a wide range of items. There is only a single point of contact, the items are turned over to socially responsible organizations and the entire process is convenient and efficient. In order to have a department's e-waste collected, the department's facility manager must arrange for a pick-up or contact UBC Waste Management's service center.

6.0 Conclusions and Recommendations

Looking to the future, an efficient IT system will continue to play a significant role in the day-to-day operations of the SUB. Three solutions for continuing this efficiency while increasing sustainability have been considered: notebooks, desktops, and nettops. In order to conduct a comprehensive study into these options, a complete, end-to-end life cycle analysis was considered. First, an examination of the typical IT use cases was done for two different sets of users. We noted that free-usage computer banks represented only a minor portion of SUB computers, and were a disappearing model. Next, we ran through several acquisition requirements that qualify the feasibility of our three solutions in terms of environmental and economic impact. Then, we analyzed the three options from a maintenance standpoint, noting differences in resource requirements for each. Finally, we looked at different options for disposing of old computer hardware and how it affects all three options.

Looking at how the three options for sustainable computer hardware stack up against economic, environmental, and social considerations, we have come to the conclusion that desktop computers with LCD screens continue to be the best solution to use. Although notebooks and nettops offer a more energy, size, and weight-conscious proposition, and might seem more environmental at first sight, their lifetime, performance and maintenance drawbacks are too significant to overlook.

It should also be noted that the landscape for computer hardware evolves at a lightning pace. As such, some of the data we have displayed in this report is subject to change. Considering the progress of computer hardware technology to date, it should continue to improve on both performance and efficiency. Additionally, thanks to increasing industry-wide adherence to directives like RoHS, the employees that manufacture computer hardware components are subject to a healthier and safer working environment. Environmental requirements should continue to have a significant impact on manufacturing and operating processes for computer hardware. As such, our recommendation for desktop computer hardware systems stands.

6.1 Additional Recommendations

While the recommendations provided in this report address issues related to sustainable computer *hardware* for the new SUB, there are a few important considerations that fall beyond the scope of this report, yet demand that we bring your attention to them.

6.1.1 Power Management Software

While the absolute power ratings of a machine are important, smart power management on up (screen settings) or down-time (standby, inactive waits) can significantly improve the efficiency of energy uses. Examples include making away with screen-savers, implementing low-power standbys, and inverting screen colour modes to be dark rather than bright. Several modern software packages, particularly on notebooks, offer extensive power management options. Furthermore, when applicable, servers can be made to operate on wake-up mode.

6.1.2 Cloud Computing

An emerging computing model is one where operations are performed over the network (internet), with dynamically scalable resources spread across it. This reduces redundancies in the system, and allows users to profit from already existing structures. It improves the efficiency of the overall system by allowing users to perform all functions they require through a browser from a simple, low-power machine, whether it be a desktop PC or PDA.

APPENDIX

Personal correspondence, email Interview with AMS IT Manager, Hong-Lok Li:

Jonathan,

Answers are below each of your questions.

Cheers.

Hong

Hong-Lok Li
Information Technology Manager

M.Sc. (Essex), CEng (Chartered Engineer, UK), CITP (Chartered IT Professional), MBCS, MIEEE, MIET, Master CNE, CCSE, MCSE, MCDBA, MCSD, Citrix CCA

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AMS: Enhancing Student Life

-----Original Message-----
From: Jonathan Lee [mailto:jlee87@interchange.ubc.ca]
Sent: Thursday, November 12, 2009 12:46 PM
To: Hong-Lok Li
Cc: cklchoi@gmail.com; dorian.gangloff@gmail.com; Jonathan Lee
Subject: Interview Questions from APSC 261 Students

Mr Li,

I spoke briefly with you last week about my group wanting to ask you questions for a UBC class project. Applied Science 261 covers topics on technology and its relationship to society with a focus on sustainability. Our final project is to propose and evaluate new options for "Sustainable computer hardware" for the new Student Union Building and our group is comprised of two Computer Engineering students and one Engineering physics student and I have cc'd them in this email. The questions deal mainly with the computer usage needs for those within the SUB (students and staff), with a focus on desktop computers.

The questions:

1. Could you please describe a typical life cycle of a desktop computer
in the SUB, from acquiring, to maintenance/upgrades, to disposal.

It really depends, some computer lasts longer than others, but generally speaking, a desktop can last six years from the time of acquisition, then going through the upgrade process until it is replaced.

2. If there is a maintenance/upgrade phase in the life cycle, could you
please provide some details on this process?

Mostly, we would upgrade memories/hard disks etc.

3. If there is a proper e-waste disposal method in place at the end of
life cycle, could you please provide some details on this process?

We would call a non-profit organization dedicated to reducing electronic waste through the reuse and recycling to take the unwanted computers.

4. What are some typical use cases for computers at the SUB? Typical
programs and applications?
 -Students/public?
 -Staff?

There are many, administration, financial transaction, payroll, public access terminals and a variety of students services, to name a few.

5. Is there any data to suggest that the computer hardware being
acquired matches the usage needs for the above cases?

NIL

5. What are your current purchasing policies with regards to power
efficiency and recyclability? For example do you only purchase "Energy
Star" rating and RoHS compliant machines?

We take these things into consideration for sure.

6. Do you only purchase new machines or would you consider buying or
accepting second hand machines from other departments on campus?

New machines only.

8. Approximately how many desktop computers are there in the SUB? Do
you expect this number to be adequate with the new SUB requirements?

There are more than 300 computers. For the new SUB, I believe there will be more.

9. Do you think laptops would be a viable option for AMS administrators?

For some, it may be. For others, it may not.

10. Have you considered some small form factor options? For example

"nettops" which are similar to netbooks in hardware using low power
components. Have you also considered a different approach such as the
use of low powered clients combined with web based applications?

We did acquire small form factor in the past but they could not serve our requirements well.

Thank you for your time, we hope to hear from you soon.

Sincerely,
Jonathan Lee and APSC 261 Group 8 (Sec. T1D)

Follow up Question:

We used it before and we still may use them again.

Cheers.

Hong

Hong-Lok Li
Information Technology Manager

M.Sc. (Essex), CEng (Chartered Engineer, UK), CITP (Chartered IT Professional),
MBCS, MIEEE, MIET, Master CNE, CCSE, MCSE, MCDBA, MCSD, Citrix CCA

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AMS: Enhancing Student Life

-----Original Message-----
From: Jonathan Lee [mailto:jlee87@interchange.ubc.ca]
Sent: Tuesday, November 17, 2009 2:11 PM
To: Hong-Lok Li
Subject: Re: Interview Questions from APSC 261 Students

Thank you for your answers Hong-Lok,

I have one follow-up question to this question:

> 3. If there is a proper e-waste disposal method in place at the end of
> life cycle, could you please provide some details on this process?

We would call a non-profit organization dedicated to reducing electronic waste through the reuse and recycling to take the unwanted computers.

Does this mean that the SUB and/or AMS does not use the current UBC Waste Management service provided on campus for e-waste disposal? (details: http://www.recycle.ubc.ca/ewaste.htm)

If not, is there a reason why?

Thank you,
Jonathan

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