Article

Impact of Open Source software on the environmental protection

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Received 6 September 2014; *Accepted 14 October 2014*; *Published online 1 March 2015*

Abstract

Ongoing development of computer hardware contributes to the constant throwing old computers ie. direct increase of electric and electronic equipment waste. This type of waste is a major threat to human health and the environment. By applying Open Source software solutions all users of computer hardware can significantly effect on the reduction of this type of waste. The aim of this paper is to present the advantages of using Open Source software package in terms of preserving and protecting the environment. This paper presents the results of testing MS Windows and Linux operating systems on an older computer, the results are obtained by applying the benchmark software GeekBench.

Keywords ICT; ecologically sustainable development; Open Source Linux; electronic waste.

Computational Ecology and Software
ISSN 2220-721X
URL: http://www.iaees.org/publications/journals/ces/online-version.asp
RSS: http://www.iaees.org/publications/journals/ces/rss.xml
E-mail: ces@iaees.org
Editor-in-Chief: WenJun Zhang
Publisher: International Academy of Ecology and Environmental Sciences

1 Introduction

Electronics industry is the largest and fastest growing global processing industry today (Radha, 2002) (DIT, 2003). The modern consumer lifestyle and rapid development of information and communication technologies (ICT) have resulted in the generation of larger quantities of electrical and electronic equipment waste. Since the 80's of last century, with the development of consumer electrical and electronic technology, countless units of electronic equipment were sold to the customers. Useful lifetime of these devices is relatively short (Kang and Schoenung, 2005). According to estimates of USA's Environmental Protection Agency, only 15-20% of this waste is recycled, while the rest end up in landfills (Vucinic and Ivanovic, 2011). Electrical and electronic equipment waste has become a global issue and a priority for resolving.

Electrical and electronic equipment waste is considered one of the major pollutants of the environment. Waste has short-term and long-term consequences on the quality and length of our lives, as well as the quality of air, food and water (Sayadi et al., 2012; Su et al., 2014). These reasons, led many countries in the world to pass strict legislation that regulates this area. In 2002, the EU adopted Directive 2002/96/EC on electrical and electronic equipment waste. Directive entered into force in February 2003, member states have been obliged to

transpose it into their technical legislation and to comply with its provisions. The purpose of this Directive is to prevent the generation of waste from electrical and electronic equipment and the one that does to be reused or processed, all with the aim of reducing of waste disposal on landfills. Some countries have organized systems for the collection, recycling, disposal and monitoring of waste electrical and electronic equipment, while others are trying to find a solution that provides jobs while minimizing negative impacts on the environment (Steubing et al., 2010).

Electronic waste is extremely hazardous and toxic. A computer motherboard and printed circuit boards of other devices contain dangerous metals, such as chromium, silver, zinc, lead, mercury, tin and copper. Electronic waste contains many substances very dangerous to human health and the environment, therefore disposal of this waste requires special treatment to prevent leakage and scattering of toxins into the environment (Sinha-Khetriwal et al., 2005).

In order to expand life-time of the use of natural resources, with minimal impact on the environment, we should change the method of manufacturing of electronic and electrical equipment, as well as prevent further dumping of this type of waste. This is essentially a concept of environmentally sustainable development, and one of the possible ways to achieve this concept is the use of Open Source software with business companies, and with individuals alike.

2 Advantages of Open Source Software

The aim of this paper is to describe the use of alternative software that can meet the needs of users using older computers that can no longer be used with Microsoft Windows software solutions. How can software improve the performance of a computer, and thus postpone throwing the computer and reducing the negative impact on the environment? When we say old computers we actually refer to the computers between the ages of 6 and 10 years, which are largely used in developing countries. At the time of their production, these computers were delivered with the operating system MS Windows XP.

In April of this year Microsoft Company has announced that they are terminating their support for MS Windows XP, which makes this system unstable and unreliable to use. To the majority of the computers now using MS Windows XP are almost impossible to run some of the newer solutions of the Microsoft Company like Windows 7 or Windows 8. In order to solve this problem, it is necessary to upgrade old hardware or buy a new one, which directly causes increase of harmful electronic waste. On the other hand, the use of Open Source Linux operating system allows continued safe and reliable operation of your old computer.

Open Source Linux operating system is free and can be used on older computers. It is also important that the European Union funded "Joinup" project, which aims to facilitate cooperation and reduce the costs of the administrative services of the state administration, both within individual countries and between member states, and all based on free software (Viduka, 2012). The problem that exists in this case is user training for the new software solutions. However, the cost of training users is certainly less than the cost of buying a new hardware. Also, by keeping old hardware one does not influence on the increase in the amount of electronic waste, which certainly has a positive impact on the environment.

The minimum hardware requirements for the latest versions of the above mentioned operating systems are shown below. This data implicates that Ubuntu Linux requires fewer hardware resources than Microsoft solutions of the same generation.

- **MS Windows 8:** Processor: 1 gigahertz (GHz) or faster with support for PAE, NX, and SSE2, RAM: 1 gigabyte (GB) (32-bit) or 2 GB (64-bit), Hard disk space: 16 GB (32-bit) or 20 GB (64-bit), Graphics card: Microsoft DirectX 9 graphics device with WDDM driver.

- **Ubuntu Linux 14.04 LTS:** 700 MHz processor (about Intel Celeron or better), 512 MiB RAM (system memory), 5 GB of hard-drive space (or USB stick, memory card or external drive but see LiveCD for an alternative approach), VGA capable of 1024x768 screen resolution, Either a CD/DVD drive or a USB port for the installer media, Internet access is helpful.

From the environmental protection stand point there are many advantages in the use of Open Source Linux operating system over the use of MS Windows operating system, such as:

- MS Windows and Mac operating systems are being sold in packaging which means that large quantities of paper and plastic are produced only for sale of the operating systems, which ultimately leads to packaging waste. Linux operating system can be freely downloaded from the Internet, whitout consumption of plastic or paper.
- Commercial applications for MS Windows or Mac operating systems, in most cases, are also being sold in packages, while most Linux applications can be downloaded free from the Internet.
- The growth of hardware requirements caused by MS Windows or Mac operating system, causes for computers to become obsolete and end up in the junkyard. Linux operates quite well on older computers. Instead of throwing them out, such computers can be used for various purposes (data storage, internet gateway, multimedia ...).
- Millions of CD media are being spent for MS Windows and Mac operating systems to be sold to consumers. Linux operating system also has to be burnt to CD before installation, however it is possible to use flash media (CD-RW, DVD-RW or USB stick) that can be reused after the installation is complete (no need to keep the installation since it can be easily downloaded from the Internet at any time).

These advantages have long been characteristic only for Open Source projects. Over time, competing companies have begun to deliver its software online thus equalizing with Linux. However, the advantage accomplished using a Linux operating system, which is mentioned in the third point, can be achieved only by using particular operating system.

3 Methodology of Research

In order to show that Linux operating system can be used on older computers, a test using benchmark software GeekBench 2.4.3 was performed. This software was chosen because it is one of the few that can be used on both operating systems (MS Windows and Linux).

For testing purposes, selected computer was purchased in 2006 and following operating systems were installed: Microsoft Windows XP Professional (32-bit), Ubuntu 12.04.1 LTS 3.2.0-67-generic-pae i686, Microsoft Windows 7 Ultimate (32-bit), Ubuntu 14.04 LTS 3.13.0-32-generic i686 and Microsoft Windows 8 Pro (32-bit).

Ubuntu Linux distribution was chosen because of its popularity among users. Table 1 shows the configuration and the operating system of the computer used to perform the test.

Table 1 The architecture of the tested computer.

Operating System	Microsoft Windows XP Professional (32-bit) Ubuntu 12.04.1 LTS 3.2.0-67-generic-pae i686 Microsoft Windows 7 Ultimate (32-bit) Ubuntu 14.04 LTS 3.13.0-32-generic i686 Microsoft Windows 8 Pro (32-bit)
Model	Acer Aspire 3690
Processor	Intel Celeron M 420 @ 1.60 GHz - 1 processor
Processor ID	GenuineIntel Family 6 Model 14 Stepping 8
Processor Codename	Yonah
Processor Package	Socket 479 mPGA
L1 Instruction Cache	32 KB
L1 Data Cache	32 KB
L2 Cache	1024 KB
L3 Cache	0 KB
Motherboard	Acer Grapevine
Northbridge	Intel i943/940GML 03
Southbridge	Intel 82801GHM (ICH7-M/U) B0
BIOS	Acer V2.90
Memory	1024 MB DDR2 SDRAM 267MHz

4 Results of the Test and Discussion

Working on the computer with the latest version of the Microsoft operating system is a much more expensive solution compared to switching to an alternative Open Source - Linux operating system. Use of the latest versions of Microsoft operating systems, demands a new license, as well as a new hardware. New equipment is necessary for unobstructed operation of the new system which is much more demanding than the previous one. Purchase of new equipment directly increases costs and the amount of electronic waste that occurs due to the rejection of the old hardware. Results of the research show that significant financial savings and environmental protection can be achieved by using the Linux operating system and its programs.

Table 2 shows the results of conducted testing. Based on the results it is obvious that there is an advantage of Ubuntu Linux 12.04 LTS compared to Windows XP in terms of utilization of the available hardware. Also, since April of this year, Microsoft Windows XP software is without support, while Ubuntu Linux is labeled LTS (Long Term Support) and is supported by 2017.

Table 2 The results of conducted testing.

Section	Description	Score				
Geekbench 2.4.3 Tryout (32-bit)		Win xp	Ubuntu 12.04 LTS	Win 7	Ubuntu 14.04 LTS	Win 8
Integer	Processor integer performance	1327	1148	1322	1155	968
Floating Point	Processor floating point performance	1207	1719	1191	1370	824
Memory	Memory performance	997	1466	1107	1092	782
Stream	Memory bandwidth performance	1025	1179	1037	754	748
Geekbench Score		1188	1414	1204	1177	858

Results show that the hardware used for testing performed very poorly with the newer versions of operating systems. When installing the operating system on the tested computer any significant problems didn't occur. In the case of Microsoft solution it was necessary to install drivers for hardware components, while in the case of Ubuntu Linux that was not needed because the system itself recognized all the available devices. It is also important to note that the operating system MS Windows was installed without other applications required for work while with the Linux operating system several dozen of application programs that are needed in everyday work were installed, such as office stationery packages and related software.

Table 3 shows the address where you can see the complete results of the testing that was done by GeekBench software for testing hardware capabilities on Linux and MS Windows operating systems.

Table 3 Addresses where you can find the complete results of the testing.

Software	Address
Windows xp	http://browser.primatelabs.com/geekbench2/2474860
Ubuntu Linux 12.04 LTS	http://browser.primatelabs.com/geekbench2/2475398
Windows 7	http://browser.primatelabs.com/geekbench2/2474868
Ubuntu Linux 14.04 LTS	http://browser.primatelabs.com/geekbench2/2474947
Windows 8	http://browser.primatelabs.com/geekbench2/2479946

5 Conclusion

Environmental protection is one of the basic principles of the national interests of each country. The only fundamental change in the relationship of man to the environment ensures continued progress of human society.

One of the solutions for the realization of the concept of ecologically sustainable development, which implies a reduction of absolute energy consumption and reduction of environmental pollution, is the use of open source software package. This paper shows how use of open source software package (Linux) can have a positive impact on the environment. Also, it stated advantages achieved by the use of this type of software package in relation to the so well-known software packages. Despite the advantages of open source software package, most companies and individuals do not use this free software. The reason for this situation is that the free operating systems (mostly GNU/Linux distribution) only a few years ago started to support enough hardware to deliver enough useful applications. Also, it is very important that now use free operating system does not require advanced IT knowledge of end-users. The aim of this study was to present the benefits of using open source software package in terms of preserving and protecting the environment. Although the study was limited by the lack of adequate literature, this paper gives a contribution in terms of opening up new areas of research, both in the field of information systems and in the field of conservation and environmental protection. Further work and research should focus on the analysis of applications of other software and their impact on the environment. Also, it is necessary to raise national awareness about the importance of preserving the environment as well as the presentation of options for achieving the concept of ecologically sustainable development. Responsible attitude and development of a culture of proper waste treatment is the basis for creating a healthy environment as a sound basis for a higher life quality.

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