EnviroInfo 2009 (Berlin)
Environmental Informatics and Industrial Environmental Protection: Concepts, Methods and Tools
 ISBN: 978-3-8322-8397-1

Green IT & Green Software - Time and Energy Savings Using Existing Tools

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Abstract

Green IT is steadily gaining ground among companies and organizations worldwide but the understanding of its actual significance is often indistinct. The purpose of this paper is to investigate Green Software and to summarize different points of view on Green IT and clarify some actions to be taken towards using computers more wisely. Special attention will be paid to Green Software and exploring what factors could make software being used and developed with the environmental impact in mind. A descriptive research method based on available literature has been used. Finally a test was set up to control if the amount of data sent over the Internet could be lowered during navigation by changing a server setting. The intention was to prove that Green Software can be simple use of tools we have at hand, just adding a small amount of knowledge. The result showed that there are savings to gain with no effect on overall performance. To conclude, a holistic approach towards Green IT and all it's including parts is necessary, together with appropriate ways of measuring progress towards improvement.

Keywords: *Green Software, Energysavings, Green IT, HTTP request*

1. Introduction

Due to the increased focus on climate change Green IT has become very popular during the last few years. But the lack of clarity about Green IT has led to wide spread confusion and Green IT embraces a far greater field than only the hardware components. This work will sum up some of the intentions of Green IT and point out its basic ideas. When it comes to software, it is mostly used in order to benefit from its secondary effects. Little has been written about Green Software. No precise definition of Green Software or guidelines of how to measure performance that can be connected to Green Software or Green Software development initiatives are to be found.

Today, climate related issues are present in all areas of society and the environmental impact caused by computers is likewise gaining importance. The connection is clear. A computer needs energy in the form of electricity to function, if the demand decreases, computers use less energy. The energy used predominantly comes from burning fossil fuels at power plants, which contributes to global warming (www.energystar.gov 13/1 2009).

The main intention with this paper is to examine the existence of Green Software and the potential ways of using software with total energy-savings at thought and to form a path of consciousness concerning the way we use computers that in the end leads to less impact on the environment. This will result in a practical test. A second objective of this document is to elucidate the concept Green IT and demonstrate where Green Software enters the scene and to describe, explain and motivate the importance of such knowledge and behaviour. This is done by means of a descriptive research approach.

2. Definitions of Green IT

The first way to describe Green IT is by dividing IT related issues into four different fields (figure 1). This description corresponds well to the Swedish Government´s goals set for further work with IT and Corporate Social Responsibility (prop. 1999/2000:86). The star indicates the main focus area of the test carried out in the later part of this paper.

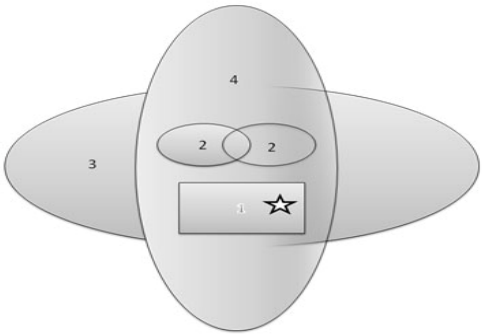

Figure 1: of IT related issues (Thorslund, Pamlin, 2004, modified)

Field 1 concerns the IT product itself and the energy and environmental impact they cause and in particular the products people use on a daily basis. This field is important to gain credibility to Green IT solutions because it is difficult to take Green IT seriously if the products needed have not been undertaken by the process of diminishing environmental impact.
Field 2 is about transportation, communication and virtual mobility. This field is pictured as two separate parts which represents the transportation of goods and the transportation of people.
Field 3 is about community planning on all levels, ranging from whole regions, cities and small towns down to the personal household planning level.
Field 4 handles the production and consumption patterns. IT opens possibilities to measure environmental impact on production and consumption and following a product or a service throughout its entire lifecycle enables control over the total environmental effect. Both field 3 and 4 are big and overall areas and all four fields affect one another in some way, hence the overlapping parts in the figure (Thorslund, Pamlin, 2004).

The importance of the lifetime aspect is pointed out in *Harnessing Green IT: Principles and Practices* (Murugesan, 2008). This paper emphasizes manufacturing, use, recycling and design of IT systems as the four main contributors towards Green IT. It also describes the procedure of taking care of unwanted computers with the three R´s; Reuse, Refurbish and Recycle. To comprehensively and effectively be able to address the environmental impacts of IT, it is important to adopt a *holistic* approach consisting of the four complementary paths mentioned above (Murugesan, 2008). A positive side effect is the economic benefit that follows.

Yet another way to look at Green IT was found in a report written to OECD by SPARU-science and Technology Policy research, in 2001. In spite of its relatively ancient date considering the fast development, the three main types of IT´s environmental effects defined seem surprisingly up to date. This is because the same division of IT´s environmental effects occurs frequently when addressing Green IT. The three main types of IT´s environmental effects are as follows:
First order impacts are the direct environmental effects of the production and use of IT, i.e. resource use and pollution related to the production of IT infrastructure and devices, electricity consumption of hardware and electronic waste disposal.

Second order impacts would be the indirect environmental impacts related to the effect of IT on the structure of the economy, production processes, products and distribution systems. The main types of positive environmental effects are dematerialization (getting more output for less resource input), virtualization (the substitution of tangible goods for information) and demobilization (the substitution of travel for communication at a distance).
Third order impacts are described as the indirect effects on the environment, mainly through the stimulation of more consumption and higher economic growth due to IT´s rebound effect1, and through impacts on life styles and value systems (Berkhout, Hertin, 2000).

It stands clear that the impact caused by IT on the environment can be positive or negative. In the process of working with Green IT the goal is to reinforce the positive impacts and diminish the negative impacts. Naturally it is easier to focus on first order impacts as they are immediate and obvious. However the third order impacts might be the most threatening ones, and the most difficult ones to approach. To begin with, the rebound effects are difficult to quantify and they operate through a variety of different mechanisms and lack of clarity about these has led to persistent confusion. Rebound effects are of sufficient importance to deserve a careful consideration. Failure to take account of rebound effects could contribute to shortfalls in the achievement of energy and climate policy goals (Sorell, 2007). Secondly, life styles and value systems do not change overnight. In all probability this area deserves an extra highlight in the ongoing Green IT debate and work. To facilitate work towards a better environment with the means of Green IT the need for a common description of Green IT is essential (Thorslund, Pamlin, 2004). The selected approach is to combine Green IT issues from both the lifecycle point of view and the impact point of view. Emphasis is also put on adapting a holistic standpoint in Green IT related work.

Effect / Lifecycle	First order impact	Second order impact	Third order impact
Manufacturing	Choice of material	Production logistics Distribution systems	
Usage	Green Software	E-commerce	
Recycling	Reuse Refurbish Recycle		

Table 1: Examples of actions towards Green IT and where impact occurs (S.Abenius 2009)

Table 1 represents the rectangle (field 1) in figure 1 (the IT related products themselves). The life cycle is the vertical column and IT´s environmental impact represents the top horizontal row. Given this it becomes clear where Green Software stands in relation to the complete concept of Green IT. However it is often difficult to determine whether the biggest impact of an action is of first, second or third order, due to the fact that many actions have an impact that reaches over both, or all three orders. In the column for third order impact there are mostly negative effects and a perfect scenario would be to find the appropriate methods and actions needed to diminish the negative effects.

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1 ***Direct rebound effect***: for example fuel efficient vehicles make travel cheaper, consumers choose to drive further and thereby offsetting some of the energy savings achieved .
Indirect rebound effect: similarly an owner of a fuel efficient car spends saved money on overseas flight, ergo; reductions in energy demand will translate into lower energy prices which encourage increased energy consumption.
Rebound effect: Sum of direct and indirect rebound effects often as a percentage of expected energy savings from an energy efficiency improvement. A rebound effect of 20% means that 80% of the expected savings are achieved (Sorell, 2007). Often used in energy saving aspects.

3. Green Software

3.1 Speed

When discussing Green IT and the holistic approach, it has become obvious that one aspect of the computers lifecycle is missing. That is usage. We have become extremely sensitive about speed when for example browsing the Internet. A waiting time that exceeds 2 seconds considerably impairs the allover surfing experience according to a summary of studies of users' tolerable waiting time (Köpsell, 2003).
With the aim to cut electricity costs or speed up a web site or both, there are pre developed tools on the market. One such tool is the Runtime Page Optimizer (RPO) (www.getrpo.com). The RPO enhances a website's performance applying a three-step optimization process to each webpage that consists of combining, compressing and cache the combined resources on the server and then send them to the browser with far-future-expiry-header set. (Rapid Page Optimization, 27/12 2008). In the book *High Performance Web Sites* (Souders, 2007) exactly the same actions are recommended as a measurement to obtain faster web sites. To find out if a web page needs optimization there are various ways of finding out. One way is using the AOL page test (www.optimizationweek.com). It gives detailed and accurate HTTP traffic breakdowns and suggests speed optimization techniques that are very similar to what RPO does.

3.2 Energy monitoring

Another way to achieve something that could be classified as Green Software is to use any of the existing energy monitoring tools to manage power use. These kinds of tools allow visualization of the power consumption and possibilities to chose the level of energy savings and calculation of estimated savings among other features. Examples of this kind of tools are IBM Active Energy Manager and Edison by Verdiem.

3.3 Speed with new inventions

Talking about software itself as being green or sustainable, it is inevitable to mention the Swedish company Oricane founded in 2006 by Ph.D. Mikael Sundström. Oricane develop what they claim to be Green Software technology for many Internet applications with the intention to reduce the total power consumption of the Internet and minimize the environmental impact of Internet's explosive growth. This is to be done by optimizing all decision processes in software with new patented algorithms. Ultimately this will reduce the power consumption of the hardware on which the Internet is built. (Breakthrough in Green Software Technology, 14/1 2009).

3.4 Grouping of Green Software

So far, three different groups of Green Software have been mentioned. Monitoring and measuring power load and energy consumption, increasing Internet speed and decreasing traffic load with existing tools and finally increasing speed by new inventions such as smarter algorithms to improve efficiency of the decision process in Internet searching.

	Green Software		
Grouping	**Existing tools**	**Existing tools**	**New inventions**
Actions	Monitor and Measure	Speed	Speed
Actions exemplified	Monitor and measure in order to optimize energy consumption.	Increase internet speed and decrease traffic load, manipulating software.	Increase internet speed and decrease traffic load, with efficient algorithms.

Table 2: Grouping of Green Software actions (S.Abenius 2009)

The result is a suggestion of categories for Green Software actions. The different actions for the grouping are: *Monitor and Measure* that belongs to the group *Existing tools* and *Speed* which refers to increasing speed with the help of *Existing tools*. The last action, also named *Speed*, is referred to as increasing speed by means of *New inventions* like more efficient algorithms (table 2).

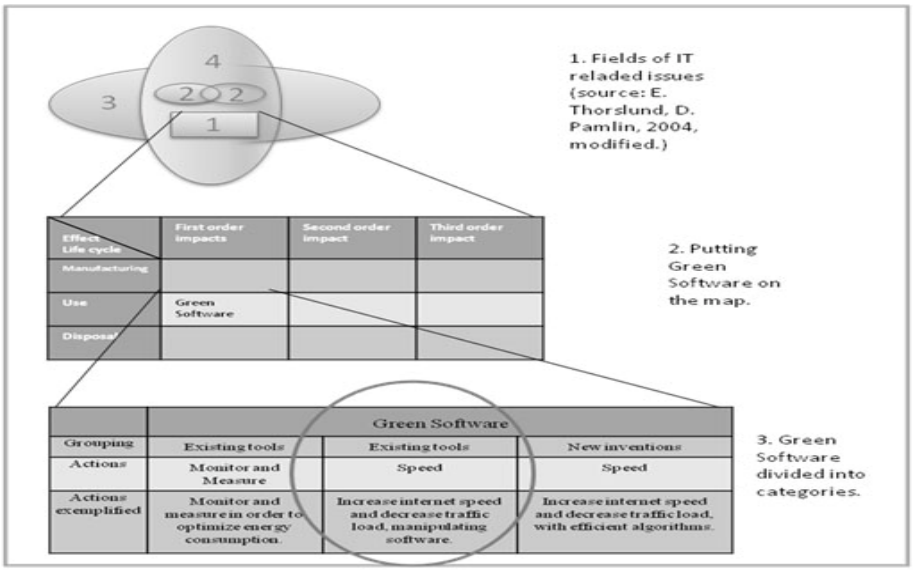

Figure 2: How fields of IT related issues are connected to tables 1 and 2 (S.Abenius 2009)

Figure2 illustrates how the Green IT aspect of the IT related products themselves (top) are viewed from both the lifecycle point of view and the impact order (middle) and how Green Software is divided into categories (bottom).

The test will take place within the oval drawn at the bottom of figure 2. This means it will be done with an *Existing tool* and intents to increase *Speed* and decrease Internet traffic load by manipulating software.

4. Test

4.1 Description of the test

The purpose of the test is to find out if it is possible to lower the amount of HTTP requests sent over the Internet during a browsing session since less HTTP requests means less work for the microprocessor and ultimately less energy consumption. This is especially interesting on web sites where the typical user returns repeatedly to the same page because when a unique visitor enters a web page for the first time; all representations of the page in question have to be requested for. The second time the user requests the same page, presupposed the user has a web cache that has not been emptied since the last visit, the existing versions of the components of the page will be used, unless a component explicitly states that an update is required (interview with Lars Nicander, Senior Web Master, IBM, 23/10, 2008).
The "expiry time" for each representation of a web page, is precisely what can be prolonged in many cases. On big web sites like You Tube or Face Book, there are certainly many components that do not need update as often as others. Elements that concern the layout of the page for example, are most likely not updated every day. Then it is recommendable to set the expiry date to eternity or in the far future, and only change it when it becomes necessary (Souders, 2007).
The test is of comparative nature. Decision was taken to do navigation on a non manipulated site (the Swedish version of IBM´s start page) and with the help of Apache log files count the number of HTTP requests generated during the session. The next step was to make the change in the server settings and to do exactly the same navigation on the same site again. The session with the modified server settings was equally followed by counting the number of HTTP requests generated. Finally, the numbers of HTTP requests from the navigation on a non manipulated site were compared with the number of requests generated after the change had been made. This was done using the Apache HTTP Server logging capabilities, which are used to analyze the result of the navigation on web sites. Having defined the different grouping of possible actions to be taken towards Green Software we have chosen manipulating software to achieve higher speed and less Internet traffic load. Trying to minimize the numbers of HTTP requests a web page generates is one of the rules recommended in *High Performance Web Sites*, (Souders, 2007) and it was chosen due to its simplicity in both testing and display of the results.

4.2 How the tests were performed

Both tests were performed on an Apache 2.2.4 server, using the Swedish version of one of IBM´s most visited pages. Before the test initiation, the browser cache was emptied. A Mozilla Firefox 3.0 browser was used. Server configuration I is defined as the Apache HTTP server 2.2.4 default settings (see below) for the module mod_expires (The Apache Software Foundation, 14/1 2009) and also the original settings for the server used at IBM that handles the live version of the web page.

```
1.  <IfModule mod_expires.c>
2.      ExpiresActive on
3.      ExpiresDefault "now"
4.      ExpiresByType text/html "now"
5.      ExpiresByType text/xml "now"
6.      ExpiresByType text/css "access plus 8 hours"
7.      ExpiresByType text/plain "access plus 8 hours"
8.      ExpiresByType application/x-javascript "access plus 8 hours"
9.      ExpiresByType application/x-shockwave-flash "access plus 8 hours"
10. ExpiresByType application/pdf "access plus 8 hours"
11. ExpiresByType image/gif "access plus 8 hours"
12. ExpiresByType image/png "access plus 8 hours"
13. ExpiresByType image/jpeg "access plus 8 hours"
14. ExpiresByType image/x-icon "access plus 8 hours"
15. ExpiresByType video/x-flv "access plus 8 hours"
16. ExpiresByType video/quicktime "access plus 8 hours"
17. </IfModule>
```

Server configuration II is identical apart from one change in line 4. The change is only setting the expiry time to “8 hours” instead of” now”:

```
4. ExpiresByType text/html “8 hours”
```

This means that the web server tells the web client to use the current copy of the text/html file, saved in the cache memory, if a new request for the page occurs within the time set, calculated from the first time the page was cached. In this case 8 hours (Souders, 2007). The above applies for both tests that were carried out. (The October and the November test.)

4.3 The tests

Before testing, the browser cache was emptied. 6 mouse clicks were done on the 3 tabs on top of the page hence 2 clicks for each tab. Each tab on the page has the properties of a separate page, which means each tab contains new representations for the complete page to download although it might appear to the user the page has not changed more than a small part, like for example the appearance of a new menu or a new picture. Apache HTTP server´s log files have then been used to take a closer look at what information was sent over the Internet.

The November test was performed on IBM´s start page for Sweden in a similar manner. Navigation was done to and from the main start page before any server settings were manipulated and the same procedure was carried out after the change in the module mod_expires had been done.

4.4 Test results

The letters A, B and C are the different pages. Numbers represent the visit, first, second, third etc. The X axis represents visits (clicks) made on the page. The Y-axis represents number of HTTP requests generated at each visit. The test showed that after doing the server changes the number of HTTP requests decreased the second time a page was visited. This occurred according to expectations in both the October and the November test (see table 3).

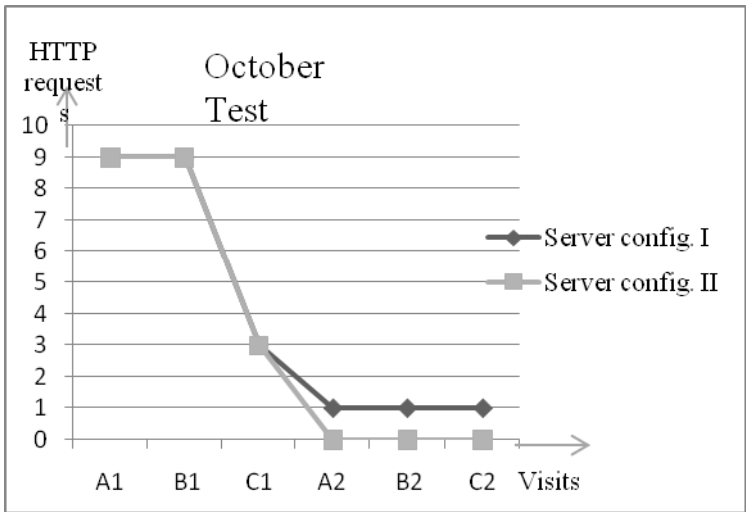

Table 3 Number of HTTP requests before (server config. I) and after (server config. II) server change in the October test (S. Abenius 2009)

Table 3 shows the result of the October test. A, B and C are all considered unique pages because they possess the complete information needed to form a page. With server configuration I page A and B generated 9 HTTP requests on the first visit and page C generated 3. The second time the page was visited the page generated 1 HTTP request. Server configuration II showed the same result but with the difference that on the second visit zero HTTP requests were made on all pages. The same result pattern was detected in the November test.

4.5 Analysis of the test results

The result of the tests showed that the second time a page was visited the page generated one HTTP request with server configuration I. With server configuration II, the second visit on a page did not generate any HTTP requests at all. This means that with server configuration II, one HTTP request is saved each visit, in other words each click or each time the page is called upon. So disregarding of how many times a page is visited, with server configuration II, no more HTTP requests will be generated for as long as the expiry time is set. In this case eight hours.

5. Conclusions and Further work

Green IT can be described as when a company, an organization or a person looks at possible areas in society where IT related work can be used to reduce the final carbon dioxide emissions. This is done through first, second or third order impacts with a holistic approach, considering the complete lifecycle aspect. A prerequisite is to have access to appropriate methods for measuring performance. There is no common definition of Green Software but energy savings connected to software and in particular web sites are being treated seriously. CO2stats (www.crunchbase.com) helps website owners understand the electricity usage and related carbon emissions associated with site usage. With the help of existing software for monitoring and measuring energy use and the increase of speed together with the smaller amount of data sent in cyberspace there is time, energy, money and ultimately CO2 emissions to be saved. Realizing a test on Green Software was feasible. Moreover the test result turned out to be of positive nature. The result states that there are possibilities to lower the Internet traffic load with little effort. On the test pages the impact

may be minimal, but with one small change in the server settings, the amount of HTTP requests were zero at the second visit, and will continue to be, for as long as the expiry time is set, disregarding the amount of visits. Putting this in a greater concept where visitors are millions and repeated visits occur frequently, like on Yahoo, Google, You Tube or any other of the top ten ranked visited web pages in the world[1], it is easy to imagine the difference it can make. If, in addition all other recommendations to speed up a web site were to be followed on all pages on the entire Internet the change would be even greater.

Another area that deserves attention is the rebound effect of IT use. As table 1 illustrates there is a great lack of knowledge concerning how to confront the third order impacts that a computerized existence brings upon us. A closer look on how the past years extremely rapid growth of computer speed and capacity has changed our living patterns and value systems can serve as a starting point for developing new ideas on how to manage and diminish the rebound effect.

Finally it has turned out during this work progress that it is of profound interest to find out more about the attitude towards Green IT among companies and people working with IT, since a great part of the material studied contains guidelines, recommendations, rules and regulations set by organizations and governments. Presumably most of the above is developed by people that work quite far away from the actual everyday IT users at an office and this is where a common culture of awareness, changes of attitude and ingrained behavioral patterns start their growing ground. Without this kind of change many rules, regulations and recommendations are almost certainly in vain.

Acknowledgements

This paper is based upon my Thesis for the Degree of Master of Science at the Department of Information Science at the Computer Science Division, Uppsala University in January 2009. A special thanks to my supervisors Anneli Edman (Ph.D., Director of Studies) and Fredrik Bengtsson (Ph.D. student).

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