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Environment Friendly E-Environments – Challenges and Perspectives

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Abstract: This paper presents challenges and perspectives of developing green e-environments. The conception of e-environments that proliferates smart devices engulfing nearly all the activities of our everyday life is facilitating the vision of modern living. However, the negative impact of these scalable technology-rich environments on the global warming is unfortunately nontrivial. It is quasi impossible to opt for the abandonment option as these environments are becoming an inalienable part of our normal lives. This paper illustrates how the energy efficiency can be achieved by using interconnected data and computing resources. A case study of Grid computing is presented to demonstrate the possibility of lowering carbon footprints by using interconnectivity. Moreover, business benefits of these paradigms are also explored as financial aspects are by and large heavier than technological aspects. Based on this work, a number of recommendations for longer term research agenda for greener e-environments are also made in this paper.

1. Introduction

According to a World Bank report on ICT (information and communication technologies) and global economic growth, the pace of digitization is over double the pace of globalisation [1]. This spectacular speed of ICT growth has exorbitant impact on the worldwide carbon dioxide (CO2) emissions. It is estimated that CO2 emissions of the ICT industry exceeds the carbon output of the entire aviation industry [2]. While the information technology is seemingly taking its toll on the global environment, it is indispensable to identify the ways and means of developing environment-friendly systems and technologies. It is also very important to assure the environment protection throughout the lifecycle of technological products from their fabrication to their disposal. There is a strong need of tackling these challenges in the global perspective as the scope of this problematic cannot be addressed by regional or continental approach. In this context, outsourcing maybe a short-term relief for some nations [3]; but in reality it is like sowing the seeds of disaster for the entire community of global citizens.

ICT like other technologies is contributing to global warming; however, it can be part of a solution. It is already used in technology solutions for monitoring pollution levels, detecting toxic materials, etc. It is also used for raising awareness by providing access to useful information resources. In this paper, we put emphasis on this side of the picture where new ICT solutions can be conceived for the protection of global environment. For example, the next generation networks (NGN) are expected to reduce energy consumption by 40 percent compared to today's public switched telephone network (PSTN) [4]. We have performed a case study of 'Grid Computing' to explore the vision of 'sharing resources implies sharing (lowering) carbon footprints'. We have also analysed the impact of Moore's law on the ecology as the hardware device upgrades generally result in the discarding of old equipments. We have envisioned the post Moore's law era in terms of electronic waste

management and in terms of carbon footprints. Business model for Grid computing paradigm is also discussed in this paper.

2. Objectives

The main objective of this work is to provide a pragmatic analysis of the role the information and communication technologies can play for the improvement of global environment in general and of e-environments in particular. Our aim is to present both technical and business interests for the evolution of environment friendly e-environments. The potential challenges and the perspectives of this approach are investigated so that a compelling case can be prepared.

3. Methodology

The methodology used for this work includes a case study of Grid computing.

3.1 Introduction

Grids enable access to, and sharing of geographically distributed heterogeneous resources such as computation, data and information sources, sensors and instruments, for solving large-scale or complex problems. The deployment of Grid infrastructures is now getting momentum after its humble take off from the e-science field over a decade ago. Grid infrastructure is always considered as the best possible solution to accommodate the high volume data produced by contemporary scientific applications [5]. Now Grid computing is emerging as a critical infrastructure for knowledge based economy and is going to be a crucial component of its day-to-day business [6].

Grid computing harnesses the computing and storage capacities of several single computers (also called nodes). The computing jobs are divided over these nodes that enable the simultaneous processing of the various tasks associated with the submitted job. This concurrency not only paves the way for time efficient completion of jobs but also reduces maintenance costs of hardware and software. This scheme also reduces the carbon footprints; e.g. a single computer does not require sophisticated cooling system whereas a dedicated supercomputer does. Grids provide virtual interface to its users so that the underlying complexity of the Grid architecture is taken off from their eyes.

3.2 Case Study

We analysed various aspects of Grid computing paradigm to investigate its potential of providing environment friendly e-environment. The findings of this study are summarized in this section.

3.2.1 Reduction of Heat Generation

Grid paradigm promotes the use of a large number of commodity type servers instead of using a small number of heavy duty symmetric multiprocessing (SMP) servers. The heat generation and carbon footprints of the SMP servers are great challenges faced by the supercomputing centres. The costs associated with their maintenance and cooling is quite high and consequently their impact on the global environment in certainly non-negligible. Small servers and desktop computers generally do not even require air-conditioning for their routine operations. The amount of heat they expel to the environment is not more than the amount of heat released by a couple of humans. They are by and large kept cooled with the natural circulation of the fresh air.

3.2.2 Dispatch of Computing and Storage Jobs to the Energy Efficient Sites

Grid resource broker is a policy driven agent that dispatches the jobs to the appropriate nodes for processing. The definition of ‘appropriate node’ in this context is driven from the

policy of the Grid test bed or from the policy rules of specific virtual organisation (VO) [7]. We can therefore easily envisage the scenario where the Grid/VO policy rules include the clauses that favour the use of environment friendly solutions. For example, priority rule for the selection of a suitable site may depict that "jobs be sent to those sites which employ renewable energy resources". Such policy rule will influence the business model as well because the Grid infrastructure providers' business interests will be associated with the use of renewable energy resources for their establishments.

3.2.3 Facilitate Conception of 'Carbon-Alternative' Applications

The human population is often obliged to participate in 'carbon-generating activities' such as travelling to distant public administration offices; printing voluminous documents for their mass distribution (e.g. yellow pages); commuting to libraries to read the reference books; etc. If we can offer a dependable information technology infrastructure whose utilisation is endorsed by the competent authorities through formal legislation(s) then a big number of carbon-generating activities can be brought to an end. The Grid can realise this paradigm by offering a reliable infrastructure for performing the afore mentioned activities from distance. The legal and social aspects can not be sorted out before the provisioning of some trustworthy Grid test bed, like the reliable internet backbone was made available before embracing the e-business era.

3.2.4 Software Based 'Renewable Applications'

The concept of 'software defined radio (SDR)' [8] is already envisioned and it is seen as future generation of mobile technology. This concept can be extended to cover various other domains where faulty or outdated hardware components are simply thrown away. For example, CDs and DVDs. Grid has the potential of providing efficient distribution of digital contents. If relevant applications are developed that can assure the proprietary rights etc. then a large segment of electronic waste management will be automatically solved like the development of 'media player' has solved the problem of scrapping tape recorders. Grid application developers can envisage the optimal transformation of the current features of the hardware components into their software equivalent for their environment friendly reusability.

3.2.5 Vision for the Post Moore's Law Era

Moore's Law [9], which has been so reliable for so many decades, now seems to be on the verge of losing its relevance [10]. Scientists and engineers have started working on the strategies for the technological solutions that can provide them needful capability of having enhanced capacities for the upgrades of their future endeavours. Grid has the potential of providing a fascinating vision of enhanced computing power in the post Moore's law era due to its capability of harnessing the computing powers of individual computers in a coherent way. Moreover, it's ostensibly environment friendly solutions make it an ideal successor for the Moore's law. Grid is going to transform Moore's "hardware-based evolution" into "software-based evolution" of computing paradigm.

4. Technology Description

Analytical analysis is used to investigate the impact of various technological factors (both hardware and software) on the global environment. The emerging technology of Grids is targeted for this work as it is indispensable to go along with the new technologies due to their anticipated wide range acceptance in the society. Moreover, it is not realistic to propose an absolute abandonment option for the novel technologies as they are rapidly becoming an integral part of our daily lives. Interpolation and extrapolation of

technological evolution especially the Moore's law is carried out so that the impact of this evolution on the electronic waste management can be analysed.

5. Developments

A holistic paradigm to investigate the impact of e-environments on the global environment is developed for this work. A set of recommendations is also prepared for the issues that are not generally fall under the category of mainstream technological concerns, e.g. issues related with other technologies such as material sciences; legal issues such as the legal character of the e-documents; social issues such as the awareness programs; etc.

6. Results

The impact of ubiquitous computing on the global warming is already studied in [11]; however, there is no precedence of the identification of holistic paradigm of the impact of E-environments on the global environments. The follow-up of the work in [11] can be facilitated on the basis of our work, e.g. a comparative analysis of paper versus gadgets that can demonstrate that how much energy costs of producing and printing the paper products (such as road maps, hotel menu, etc.) can be saved by using electronic gadgets; and how the waste management of the aging gadgets be handled in the environment friendly manner. Such a fine grained relationship of paper costs versus electronic waste management costs can provide compelling case for treading towards the technology rich era yet assuring the existence of green environment. This study is necessary for the development of benchmarks to measure the carbon footprints and consequently the evolution of best practises.

We have also analysed the impact of Moore's law on the ecology as the hardware device upgrades generally result in the discarding of old equipments. We have envisioned the post Moore's law era in terms of electronic waste management and in terms of carbon footprints. Moreover, business models for this paradigm are investigated and the benefits are summarized in the section 7 of this paper.

7. Business Benefits

Computational Grid gives a fascinating business prospects as overall data processing costs can be reduced drastically. The reduced processing time on the Grids due to the parallel processing of a job's various components not only lead to the early release of the products into the market but also the overall product price is slashed thanks to quicker and cheaper preparation phase. Although the Grid paradigm still lacks sound security, trust and dependability solutions besides fine-grained billing and accounting models; yet business interests are forcing big companies to invest in this area.

The policy based resource management feature of the Grid can be used to fetch the computing jobs to the sites which are using the renewable energy resources or the sites which produce less CO2 than their counterparts. The global sharing of resources has the potential of significantly reduce the use of papers (and consequently printers, cartridges, etc.) as the various stakeholders can use the electronic means to access and process the documents that are otherwise presented to them in paper format.

The Grid paradigm is helpful for telecommuting where people can work from home. Telecommuting is gaining importance today not only for its better impact on the employees' performance but also for the savings associated with this mode of working. According to a survey of the Belgian Wallonia (French-speaking) region, telecommuting is ranked fifth of thirteen solutions to fight against climate change [12].

8. Conclusions and Recommendations

Impact of technology on environment is important with the rise in the global warming. This paper presents the challenges and perspectives of deploying the environment friendly e-environments by using a case study of a contemporary computing paradigm known as Grid computing. The associated concepts such as the scope of hardware evolution to pace overall technological developments and business benefits are analysed. A set of recommendations for long term research agenda is presented here:

- Research on electronic materials and their compositions so that their recycling be made more efficient in such a way that no waste is produced in their lifecycles.
- Coordination is needed with the research developments in other domains. Examples include efficient cooling systems for server/cluster rooms; noise reduction solutions; social engineering methodologies, etc.
- Comprehensive e-Solutions such as E-Government, E-Business that can help curtail the use of papers in the real life administrative and trade situations. Besides technological solutions, legislations are also needed for the equivalence of electronic documents in the legal jurisdictions.
- Possibility of introducing 'environment surcharge' for the IT stakeholders that can be used for planting a tree for every IT unit's fabrication.
- 'Green targets' given by the funding agencies such as ANR in France, IST in Europe, NSF in USA, and DEST in Australia.
- Last but not least is the 'awareness' programs that can persuade people especially young people to play the games in the field rather than playing with the disposable electronic gadgets. For the employees, the concept like 'no email day' [13], etc.

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