Green Computing Research Challenges: A Review

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Abstract: At present Green Computing is under the consideration of businesses organizations and IT industries. With the advancement in variety of applications and user demands the infrastructure and resources are increasing exponentially. In past few years, computer and IT industry have realized the importance of going green, both in terms of environmental issues and minimizing costs which has led to remarkable drift in strategies and policies of IT industry. The motivation behind this change comes from the ever increasing business computing demand, ever growing cost of energy, rising awareness of global warming issues. This paper presents several green initiatives under way in the IT industry and in brief covers the main research challenges which are still open in the race to meet green computing requirements.

Keywords: Green computing, Energy cost, Data centers, green initiatives

I: Introduction

Computer systems are becoming increasingly ubiquitous and a part of the global infrastructure, resulting in large installations of computer systems to provide multiple services. With the advancement of computing applications and need of IT among people the efficient technologies are being developed. Computers and other computing applications have certainly made a big impact globally but the other part of the technology usage is alarming. According to Jevons’s paradox [4], technological progress that increases the efficiency with which a resource is used tends to increase (rather than decrease) the rate of consumption of that resource. This paradox is well supported by Moore’s law [5], 2005 which predicts exponential growth in the power density, and total power used for IT. On the contrary there is linear growth in power generation mechanisms. As long as computers are running, require power to run, they produce heat which requires cooling mechanisms, another significant consumer of electricity and also becoming responsible for the production of a relevant portion of the overall CO2 emission, as well as greenhouse gases (GHG), which are easily injected into our ecosystem. This is a real problem, and recently, the Organization for Economic Co-operation and Development [1] developed different initiatives for reducing the power consumption of both computing and networking devices [2, 3]. In analogous, the research and academic worlds also initiated a new research area, which has been named green computing. To address recent concerns about global climate change and the energy crisis Green Computing has become popular. Section 2 gives a brief introduction of green computing. The various green initiatives under way are analyzed in section 3 and finally in section 4, the green computing research challenges are discussed.

II: Green Computing

Green computing is the practice of using computing and IT resources proficiently. As a human being it is our prime responsibility to protect the environment and save energy cost in today’s increasingly computing requirements. Green computing or Green IT, is the analysis and practice of environmentally sustainable computing or IT. According to San Murugesan "designing, manufacturing, using, and disposing of computers, servers, and associated subsystems—such as monitors, printers, storage devices, and networking and communications systems — efficiently and effectively with minimal or no impact on the environment” [6]. The need of green computing is to diminish the use of harmful equipment, increasing energy efficiency, and to promote the reusability of computing devices and IT waste. Green computing provides hope and practical strategies for the future. Thus, green IT includes the scope of environmental sustainability, the economics of energy efficiency, and the total cost of possession, which includes the cost of disposal and recycling. It is the study and practice of using computing resources efficiently[7]. Some of the major characteristics of green IT includes consolidation, and cloud computing (8). IT companies can merge different areas to save on hardware, to respond to merge security threats, and to conserve energy by reducing power usage and cooling.
requirements. Current IT setup relies on integration of users, networks, and resources for which green computing idea must be applied to address increasingly difficult problems.

Green IT can be reached through reduction of energy consumption and waste. Energy management and emissions tracking software are available. What the IT buys – from computer equipment to paper – directly impacts how green IT is and how green its suppliers are. If an IT organization only purchases technologies with Energy Star, EPEAT, and other energy efficiency ratings, it can significantly reduce its energy consumption and greenhouse gas footprint, and it will help drive technology manufacturers to develop products that earn energy efficiency ratings. At the end of the chain, a green IT function needs a waste management program.

III: Green Initiatives In Information Technology

It started way back in 1992, when the U.S. Environmental Protection Agency (EPA) launched Energy Star, a controlled labeling program that is planned to promote and recognize energy-efficiency in monitors, climate control equipment, and other technologies. This resulted in the widespread adoption of sleep mode among consumer electronics. Concurrently, the Swedish organization TCO Development launched the TCO Certification program to promote low magnetic and electrical emissions from CRT-based computer displays; this program was later expanded to include criteria on energy usage, ergonomics, and the use of hazardous materials in construction. With time IT industry has taken many initiatives towards green ICT (Information and Communication Technologies). The remarkable green initiatives in IT are:

1) Improved Data Center Cooling Methods: This is achieved by improving the data center cooling configuration, eliminating considerable amount of energy leaks. IT can result in efficient data centers by following leading practices in data centre layout and rack and server arrangements. Effective approach include raised floors to improve airflow, moving cooling systems closer to servers to concentrate cold air in the right place, alternating hot and cool server passageway to improve airflow and using water-based air conditioning systems [9].

2) Efficient Servers usage by Virtualization: Generally, IT companies have been using many server farms or data centers, dedicated to a specific task. These data servers must be efficiently used. One of the mechanisms is load balancing which chooses the optimum resource among many. Also by using virtual software to perform these tasks, a single server may be used to power these virtual servers, dramatically reducing energy consumption.

3) Alternative Storage Methods: Storage drives are another main element of data center infrastructure and, as organizations storage needs increase; more energy is used to power these hard drives. It can be reduced by using large capacity drives and performing data center audits to eliminate redundancies in the system.

4) Using Thin Clients: With thin clients, each employee has a virtual desktop that includes a mouse, keyboard and screen while the remaining unit is shared by all at a central location.

5) Strengthen Printer’s Output Management: Centrally located printer may be used to handle all printing tasks virtually eliminating numerous machines being left on all day sucking up energy and driving up costs.

6) Explore Alternative Sources of Energy: The efficient resource utilization leads towards efficient methods to evolve [4]. With time renewable and natural energy sources are being used to power data centers, such as nuclear or hydroelectric power, solar energy etc. This saves money and generates fewer CO2 emissions.

7) Energy saver initiatives: This includes using energy saving settings and encouraging employees to turn off equipment at the end of the work day and on weekends.

8) Proper Disposal and Recycling: This is so important because it potentially eliminates the threat of harmful toxins being released into the environment and allows for the reuse of equipment reducing the amount of waste. These initiatives exhibit the requirement of going green. Along with above mentioned IT initiatives every sector and area of IT is practicing green strategy and policies because sustainable development of ICT is the future need. Still there are many open challenges in computing which are covered in following section.

IV: Open Research Challanges

Energy is one of the most valuable and scarce resources available to the world, a significant portion of which is now being consumed to power up computers and computing infrastructure. Basically, high-performance parallel and distributed computing system, including data centers, supercomputers, clusters, real-time systems, and grids not only consume considerable amounts of power but also require air-conditioning to keep the systems cool. The exponential growth in computing is rapidly increasing the consumption of precious natural resources such as oil and coal, strengthening the alarming danger of energy shortage. These issues have been raised by the researchers from time to time and the possible measures are being taken. Still there are many areas yet to be explored. Here we present some notable areas of research in green computing:

1: New Optimization Techniques in Performance-Energy-Temperature aware Computing: The exponential growth in computing activity and the rising concern for energy conservation have made energy efficiency in computers a technological issue of prime importance. The tradeoff between Performance-Energy-Temperature has to be made for so that the maximum benefits can be obtained. Designing techniques that are optimal with respect to performance, energy, and temperature are utmost requirement as far as green computing research challenges are concerned.

2: Information Resource Tier Optimization: The information resource tier represents important data base management systems in the global computation world. General paradigms include databases, directories, file-systems, and flat files. It also includes the integration of different
database structures so that different databases can be analyzed irrespective of their storing mechanisms and data structure. Big data research topic is open in this field [10, 11].

3: Reduce architectural complexity: The research area is open to reduce the number of tiers and component dependency to reduce maximum system use. Intel’s core 2 duo is a mechanism which uses power to run only those components which are necessary at any computation [12].

4: New high-efficiency data center design

Bigger data centers can be made much more energy efficient than smaller data centers. Standards are emerging for measuring this, such as the concept of Power Usage Effectiveness (PUE). PUE is defined as the ratio of total facility power divided by IT equipment power [13]. Thus, it is a measure of how much of the power being consumed by the facility is actually being used to power the IT equipment itself rather than all the other things. Therefore it will quiet be a challenge to make the bigger data centres power efficient

5: Developing Green Maturity Model: Full equipment life cycle is the main area for green maturity model, with energy reduction as the best measure of “greenness.” The need of maturity models for equipments, IT organizations, computing techniques is an issue which has been addressed by some researchers but is limited to specific areas. Green maturity model for virtualization [14] depicts that each level describes the degree of green characteristics.

7: Wireless Sensor Network for Data Center Cooling: Data center cooling is a major issue as far as power consumption is concerned. Data centers are backbone of any computing organization and must be reliable and available available at any point of time. Measuring the data center effectiveness and maintaining the baseline is an issue. Wireless sensors could play a big role for managing data centers power management [15].

8: Green Software’s: Recently, green software movement has become a research subject for most of the software developers companies because of need for sustainable development [16]. Most of the research has been done on the characterization, metrics and technical answer for green software, but few have addressed green software from the business perspective. Business organizations are moving towards green software’s and still some considerable steps need to be taken.

V: Conclusion

Green computing will be the driving force of future computing. New computing innovations and applications need to fulfill the green computing requirements for the sustainable development of Information and communication technology (ICT). Every research challenge carries a future prospect for employing efficient computing in different areas. We will further analyze these challenges for better understanding and future research.

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