High Performance Computing: Grid Computing and Cloud Computing for Green ICT

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ABSTRACT
Nowadays, power consumption in computer system is an active and important subject of discussion in both research and political communities. Advances in Information and Communication Technologies (ICT) over the past few years have shown an exponential growth during for few decades. There is a need of some strategies for solutions to optimize energy consumption in the ICT sector. Indeed, increasing the performance of such computer systems frequently requires increasing the number of resources, thus leading to higher power consumption and a negative impact on the environment. It not only ensures efficiency and reduced carbon emissions but also leads to potential cost/time savings in organizations. Intense computing actions that work on huge data, generally take hours to compute which could be reduced to few seconds using Grid Computing and Cloud Computing. The paper provides a basis for using Grid Computing and Cloud Computing for green ICT.

Keywords
Grid Computing, Cloud Computing, Energy Saving, Green ICT, HPC.

1. INTRODUCTION
Currently the ICT industry is responsible for 3% of the world's energy consumption. With the rate of consumption increasing by 20% a year, 2030 will be the year when the world's energy consumption will double because of the ICT industry [1]. Green IT emphasizes the need to adopt practices that will lead to less energy consumption and IT waste, whether dealing with small devices such as mobile phones or large energy incentive data centers [2].

The temperatures have already raised 1.40F since the 20th century [3]. Needless to say, if this is allowed to happen, the climate of the planet will be fundamentally altered, and the resulting climate change is likely to have a major impact on the ecosystems and economies of the world, more so on the poor and developing nations [4].

In fact, based on the IPCC and Hadley Center analysis, the Stern Review suggests that, the developed countries alone need to reduce their emissions by 20-40% below the 1990 levels [5, 6]. Hence, there is a pressing need to cut down the carbon emissions, use energy efficient methods and manage the resources intelligently and efficiently. Given that, there is a considerable research going

on regarding reducing the carbon footprint [7] and analysis shows that the field of Green ICT could be a major player in doing the same. Therefore, it is essential to know how energy could be efficiently managed in the ICT sector. In this paper the current status of the field of Green ICT is presented with the use of some strategies like Grid and Cloud Computing, and an analysis of some of the best practices from the Energy

2. WHAT IS GREEN ICT
Green ICT refers to environmentally sustainable computing or IT .Green IT is defined as "the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems (monitors, printers, storage devices, etc.) efficiently and effectively with minimal or no impact on the environment". This definition illustrates that the term "Green IT" is multifaceted and covers manifold aspects of environmentally sound IT solutions and practices. Since IT is a major source of environmental problems at each stage – from its production, throughout its use, and into its disposal – Green IT strives to achieve economic viability and improved system performance and use while regarding social and ethical responsibilities [8].
According to Green IT concept the building of a "greener" environment requires modifying or abolishing old and familiar ways of doing things and discovering new processes and methods. In below Figure-1 we derived a model that comprehensively addresses the environmental impacts of IT. The model illustrates three different dimensions of Green IT

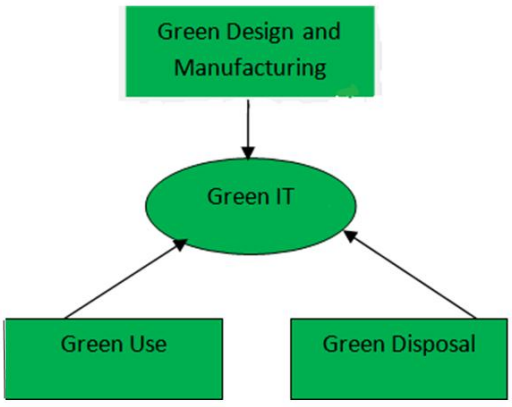

Fig 1: Various Dimensions of Green IT

3. IMPACT OF GREEN ICT

Of late, ICT has been at the forefront of technology advancements and innovation. It is one of the fastest growing sectors of the economy, and is expected to continue to grow at a more rapid rate in the future [9]. These advances in technology come at the price of increased energy consumption and increased carbon footprint. Hence ICT has a significant impact on the production, utilization and disposal of equipment [10]. Analysts say that ICT contributes to approximately 2% of the carbon footprint of the world [11]. Between 2007-2020, the ICT share of carbon emissions in the U.S alone is expected to rise from 2.5% to 2.8%, comprising an annual growth rate of 1.4% [12]. Hence it is apparent that ICT has a huge global presence, which is why the Green-ing of ICT is a very important issue. Studies have shown that as much as 65% of the people are unaware of their energy usage [13]. Therefore it is essential to analyze what percentage of ICT actually contributes to the productivity. The global footprint of the ICT sector can be better understood from Figure-2

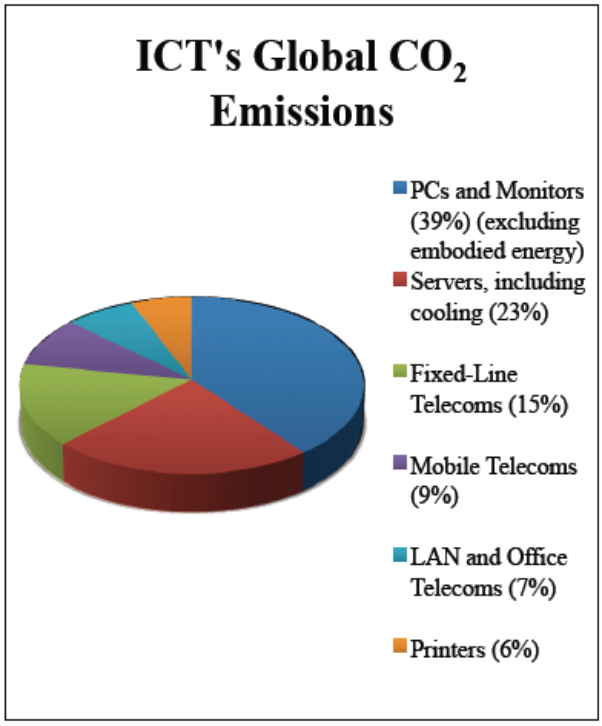

Fig 2: ICT's Carbon Footprint [11]

4. GRID COMPUTING

Grid technology provides several benefits, including seamless computing power achieved by exploiting under-utilized or unused resources, resource allocation and load balancing based on Service Level Agreements (SLAs) to meet QoS requirements, and a more reliable, resilient, and scalable infrastructure with autonomic management capabilities and on-demand aggregation of resources from multiple sites to meet unforeseen demand [14].

4.1 Implementation of Green Grid

As already described in above section 2, the environmental impact of IT can be analyzed along three different dimensions: IT design and manufacturing, IT use, and IT disposal. As presented in Figure-1. Grid technology can be used to address these three dimensions of Green IT and can be implemented as Figure-3

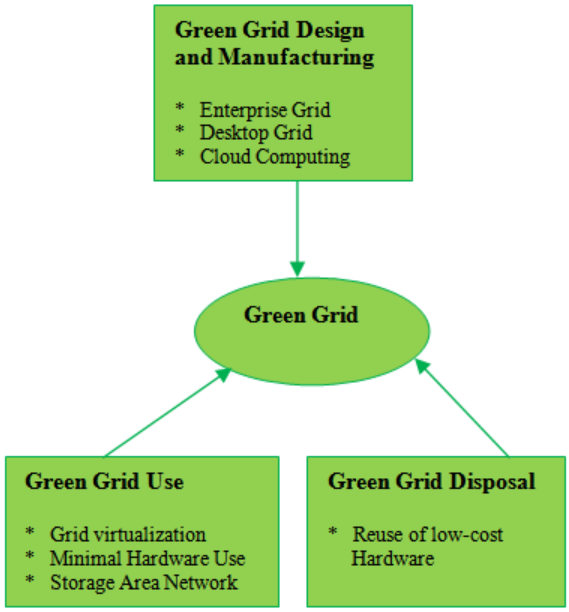

Fig 3: Implementation of Green Grid concepts

4.2 Green Design and Manufacturing of a Grid

4.2.1 Enterprise Grid

The benefits of an Enterprise Grid in regard to Green IT are higher resource utilization and significant cost savings for businesses, since they do not need to purchase expensive, high-end IT equipment that in most cases consume large amounts of power for the purpose of running their high performance applications. However, the environmental impact of a Grid could further be decreased by investing in power efficient hardware components that are integrated into the Grid [15].

4.2.2 Desktop Grid

The vision of a Desktop Grid is to harness the collective power of existing underutilized computational resources of desktop computers found in offices within an enterprise or organization [16]. Unlike a dedicated computer cluster, the resources of desktop computers cannot be accessed exclusively but when they are not fully utilized by their direct interactive users and have spare capacity. Since most of the today's desktop computers or laptops contain multiple CPUs, "cycle stealing" is a common practice in Desktop Grids while maintaining low obtrusiveness to the desktop computers' owners. Since some desktop computers are not switched off at night, during weekends, and on holidays, the resources can exclusively be utilized. Nevertheless, it is more environmentally sound to switch off computers when they are not in use.

4.2.3 Cloud Computing

Grid technology allows enterprises to purchase IT resources (mostly commonly computing or storage resources) directly from external services providers over the Internet on a use-on-demand, pay-per-use basis. In order to offer a large pool of IT

resources to customers, external services providers interconnect a large number of IT resources into a Grid and virtualized the resulting Grid infrastructure. Since the virtualized Grid is a fully scalable and abstracted infrastructure that can host a large number of applications, the Grid may also be called "the Cloud". The main characteristic of Cloud computing is that the use of Grid resources is billed by consumption.

Currently, there are only a few external providers that commercially offer Grid resources on a use-on-demand, pay-per-use basis, such as Sun Microsystems offering on-demand computing resources [17], Amazon offering on- demand storage and computing resources in form of virtual machines accessible over the Internet [18], or Google offering a Platform-as-a-Service [19].

For example, Microsoft, that is about to offer Grid resources on-demand to customers, has built a large data center in Ireland which is, due to the moderate climate in Ireland, air cooled and therefore 50% more energy efficient than other comparably sized data centers [20]. As a result, enterprises that are not able to invest in own energy efficient and power effective IT equipment have the opportunity to purchase IT resources from external services providers that have already invested in Green IT initiatives and therefore offer power and cooling efficient Grid resources leading to reduced carbon emissions.

4.3 Green use of a Grid

The environmentally sound use of IT resources can be implemented by virtualizing a Grid infrastructure and by developing a globally distributed Grid to minimize the number of servers, storage, and other IT equipment that consume significant power.

4.3.1 Grid Virtualization

Instead of having one computer for each service or set of services, you can instead consolidate each server onto a larger virtualized system that uses its resources to the fullest, and has a much smaller energy footprint. This benefit in several ways [21]:

- It reduces the total amount of hardware used in your environment
- Idle Virtual servers can be powered off
- The virtualized server will have much less idle time and waste less
- The total volume of space, air, and rent will be reduced. Data centers can use up to 100 times the energy per square foot of typical office space.
- Some power companies pay rebates for conversion to virtualized systems.

In fact, virtual servers are the simplest instance of a virtualized system some virtualization software available such as:

- VMware (http://vmware.com)
- Xen (http://xensource.com)
- Parallels
- Linux Virtual Server

4.3.2 Storage Area Networks

Consolidating Storage is an important way you can reduce the total number of disks in a datacenter. Storage Area Networks or SAN allows you to build an efficient storage network that consolidates all storage that is considerable following ways:

- Does SAN reduce the total number of disks?
- SAN allows you to avoid data duplication of OS data.
- SAN can contribute to smaller backup systems via Snapshots
- SAN gives a higher reliability factor. (Replication)
- SAN allows greater scalability, avoiding upgrade cycles.
- SAN allows tiered storage: Solid-State, SATA, SAS.

4.4 Green disposal of a Grid

Grid technology allows for the integration of heterogeneous IT resources into a Grid. Therefore, even less-powerful servers and desktop computers that are designated to be disposed of can be reused in a Grid infrastructure. As a consequence, an enterprise does not need to invest in more powerful and expensive servers to meet the ever increasing business demand for powerful IT infrastructures [22].

5. CONCLUSION

In this article we emphasizes the importance of environmentally sound practices especially in the IT industry due to the significant power consumption of IT hardware that consumes significant amounts of electricity, placing a heavy burden on the power grids and on the environment.

With the implementation of the grid and cloud computing architectures for different organization both at the private and public level the energy consumption will be lesser, if we can have efficient algorithms, proper virtualization and cooling of data centers and efficient utilization and delivery of services.

6. ACKNOWLEDGEMENT

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