A Modern Approach for Achieving Green Computing by Effective Utilization of Cloud OS

Vadivel .M[1] Hariharanan .P[2] Bethanasamy .R[3]
[1, 2, 3]M. Tech (2nd Year)
[1, 2, 3]Computer Science and Engineering Department
[1, 2, 3]B. S. Abdul Rahman University, Chennai, Tamilnadu, India

Abstract---Green computing refers to the practice of using computing resources more efficiently while maintaining or increasing overall performance. The greatest environmental challenge today is global warming, which is caused by carbon emissions. Green computing has been an active research area which studies an efficient use of computing resources. Green IT refers to the study and practice of using computing resources in an efficient, effective and economic way. Thus, it is necessary to significantly reduce pollution and substantially lower energy usage. The analysis of energy consumption in cloud computing consider both public and private clouds. Cloud computing with green environment can enable more energy efficient use of computing power. Currently, a large number of cloud computing systems waste a tremendous amount of energy and emit a considerable amount of carbon dioxide. In fact, cloud computing is an extend of Grid Computing, Distributed Computing and Parallel Computing. It's foreground is to provide secure, quick, convenient data storage and net computing service centered by internet. Green Cloud framework for reducing its carbon footprint in wholesome manner without sacrificing the quality of service (performance, responsiveness and availability) offered by the multiple Cloud providers.

Keywords: Green computing, Grid computing, Cloud OS, Cloud computing, Carbon dioxide, Distributed Computing

I. INTRODUCTION

Green Computing dates back to 1987, the World Commission on Environment and Development issued a report entitled "Our Common Future", which proposed the basic concepts of "sustainable development". This idea was recognized immediately by general environmentalists, economists, social activists and the international community. In 1992, the U.S. Environmental Protection Agency (EPA) [5] launched consumer Energy Star plan, which was designed to reduce energy consumption and decrease Greenhouse gas emissions caused by power. This program was mainly for the computer program product at first, which can be seen as the beginning of the Green Computing movement. Currently, the Energy Star program has been extended to the industries of motors, office equipment, lighting, household appliances, construction and other.

It refers to environmentally sustainable computing which studies and practices virtually all computing efficiently and effectively with little or no impact on the environment. There are several facets to achieve green computing such as designing, manufacturing, using, and disposing computing components including hardware and software. However, most green computing projects focus on energy efficiency for data centers such as IBM's "Project Big Green" with a 42% power savings [1], and a green computing project conducted at Indiana university reduces 48.3% energy by applying "sleep mode" on a cluster [2]. Cloud computing is a recent technology that concern with online distribution of computing resources and services [1]. In cloud computing, end-user knowledge about the configuration of service delivering system may not be required because client just use services on pay per model where all system configuration and resource management is taken care by cloud system automatically [2]. In cloud system, virtualization plays a very important role by allowing online sharing of computing resources [4]. Cloud systems have many types of scalable computing resources as software, hardware and data storage media etc.

In this paper, we demonstrate the importance of cloud OS known as virtual distributed operating system that binds together this cloud resources in a single-unified processing environment that helps to manage the cloud resources in a flexible and accessible approach henceforth enhancing the systems performance. Several cloud OS are available to bridge the gap between this cloud resources. The experiment is being performed on several existing platforms that allows the user to access this resources with a user friendly GUI. By making use of a cloud OS the overhead in handling the cloud resources by the running machine can be successfully reduced for a particular cloud user hence directing towards efficient use of systems resources and contributing towards the features of green computing.The cloud lifecycle can be divided into four stages, viz., designing, setup, using and disposal. Green computing in the cloud context can be achieved by ensuring minimum or no impact on environment during each of these cloud lifecycle stages. The objective is to reduce energy consumption and improve resource performance and efficiency. For this study, we identified several unexplored areas that can help in maximizing the energy efficiency of Clouds from a holistic perspective. After analyzing the shortcoming of previous solutions, we proposed a Green Cloud Framework and presented some results for its validation. Even though our Green Cloud framework embeds various features to make Cloud computing much more Green, there are still many technological solutions are required to make it a reality.

II. CLOUD DATA CENTER DESIGN

Data center design plays a very important role and is essential for creating an energy efficient data center with energy saving configuration. Creating a good data center design requires attention to be paid to the following:

Data center location:
Decide data center location factoring the data center purpose as well as availability of resources for running the data center such as cheaper electricity and skilled resources.
Construction:
of the data center building: While designing the data center, electrical systems must consider the data center landscape and wherever possible leverage the natural lighting. Other factors to be considered are local availability of renewable energy, using outside air for cooling or locating the systems where the heat they produce may be used for other purposes.
Resources:
The selection of a resource to be used in the data center must be based on lower energy consumption by the resource.

This will help reduce the running costs. other steps include using efficient air management, cooling and electrical systems while designing data centers. Terminal servers have also been used in green computing. Users connect from their terminal to a central server. Though all the computing is done at the central server, the user experiences the operating system on the terminal. Combining of terminal servers with thin clients that use about one-eighth of the energy of a normal workstation, result in decrease of both energy costs and consumption.
Configuration:
Align all IT processes and systems with the core principle of sustainability. The IT systems should be designed from the cloud perspective and must help leverage the benefits of the cloud. Many operating systems provide Advanced Configuration and Power Interface (ACPI), an open industry standard that allows an operating system to directly control the power saving aspects of its underlying hardware.

Data center must be designed so as to ensure appropriate cooling throughout the data center. It is crucial to use energy efficient cooling systems in the data center and intelligent systems for temperature control within the data center. As Cloud data centers are located in different geographical regions, they have different CO2 emission rates and energy costs depending on regional constraints. One must also provide for alternative power supply for use in case of disaster, setup processes for regular system maintenance and conduct periodic checks to ensure that the systems are functioning properly. The above considerations will help arrive at a good design resulting in better space utilization and increased performance and efficiency. Each resource has a lifespan. One can contribute to green computing by increasing the resource longevity by including upgradability and modularity. For example, it is said that manufacturing a new PC makes a bigger ecological footprint than making a new RAM module to upgrade an existing one.

III. EFFORTS FOR GREEN COMPUTING

"Cloud Computing Meets Energy Management," William Clifford makes important points about the need to optimize the efficiency of both cloud data centers and on-premise computing. However, a new study released this week challenges his assertion that cloud computing "just transfers the consumption problem to another location." The findings suggest instead that cloud computing can significantly reduce the overall net energy use of business computing needs.

Microsoft, where serve as the company's chief environmental strategist, commissioned Accenture and WSP Environment & Energy to analyze the energy use and greenhouse gas (GHG) emissions for on-premise vs. cloud-hosted deployments of three widely used Microsoft applications for e-mail, content sharing and customer relationship management. The study assessed the carbon footprint of server, networking and storage infrastructure for three different deployment sizes (100, 1,000 and 10,000 users), finding that the smaller the organization, the larger the benefit of switching to the cloud.

When small organizations (100 users) move to the cloud, the effective carbon footprint reduction could be up to a 90% savings by using a shared cloud environment instead of their own local servers. For large corporations, the savings are typically 30% or more. In a case study with a large consumer-goods company, the team calculated that 32% of energy use and resulting carbon emissions could be saved by moving 50,000 e-mail users in North America and Europe to Microsoft's equivalent cloud offering.

Think of cloud computing as being like mass transit. The data center is essentially getting computing applications to carpool or take the bus instead of sitting in their own individual servers. However, unlike mass transit, there is no sacrifice in convenience or performance with this move. Consider the disappointing fact that a typical server in a company often runs at about 10% of capacity, meaning there are lots of servers out there drawing power without doing much computing. Like single-occupancy cars, those servers use up much of the same energy that they would if they were running at full capacity computing and effective measures to boost efficiency of on-premise computing, IT professionals can and indeed must invent a far more efficient and sustainable computing infrastructure.

The efficiency benefits of the cloud won't be realized unless customers are thoughtful about decommissioning or repurposing unused servers, and cloud providers like Microsoft continue to innovate in the name of greater and greater efficiency. We believe all IT operations should look to tools (like virtualization) for enhancing server utilization and decreasing the total number of servers required for a particular computing need. But rather than think of companies outsourcing some of their energy use and carbon footprint to cloud operators, this study suggests that a shift to cloud computing creates an opportunity for many organizations to realize efficiencies and carbon emissions savings not possible with their existing IT infrastructure. For companies with their own large-scale infrastructure, this study identifies the key drivers that will let them optimize for the greatest efficiency as well. With the thoughtful use of both cloud computing and effective measures to boost efficiency of on-premise computing, IT professionals can and indeed must invent a far more efficient and sustainable computing infrastructure. As demand for cloud services continues to increase, so too does the energy consumption of service providers' data centers and, ultimately, their negative impact on the environment. Although some providers are actively trying to reduce the irreversible damage that high-carbon

emissions their facilities wreak on the environment, most providers have other prerogatives that take precedence. Environmental responsibility for its own sake might not be topping the priority lists of many cloud providers, but perhaps it should. Here's why: High energy consumption results in high operational costs, which eat away at overall profits. Going green doesn't have to be a daunting task. SearchCloudProvider.com has many resources that can help you explore ways to improve energy efficiency in your cloud services environment without hassle. much computing. Like single-occupancy cars, those servers use up much of the same energy that they would if they were running at full capacity. Going green doesn't have to be a daunting task. SearchCloudProvider.com has many resources that can help you explore ways to improve energy efficiency in your cloud services environment without hassle. When added up across all businesses worldwide, the energy efficiency the cloud provides has a significant impact on curbing further damage to the environment. This is not a fact to take lightly when companies are aiming to be more responsible for the environment.

IV. GREEN CLOUD OPERATING SYSTEM

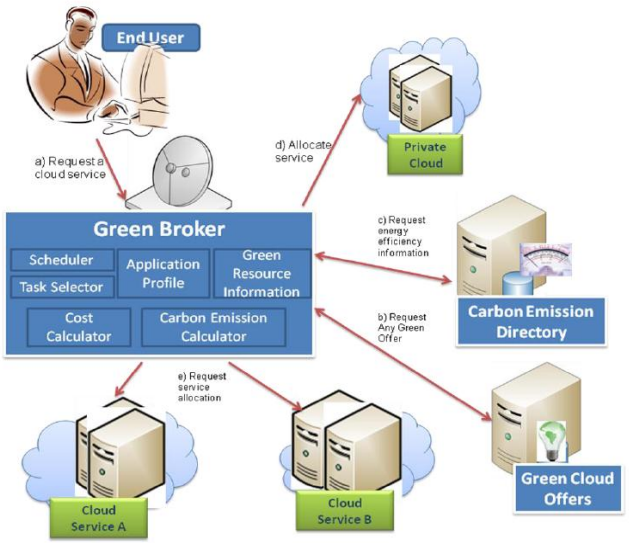

Fig. 2: Green Cloud Architecture

In the Green Cloud architecture, users submit their Cloud service requests through a new middleware Green Broker that manages the selection of the greenest Cloud provider to serve the user's request. A user service request can be of three types i.e., software, platform or infrastructure. The Cloud providers can register their services in the form of „green offers" to a public directory which is accessed by Green Broker. The green offers consist of green services, pricing and time when it should be accessed for least carbon emission. Green Broker gets the current status of energy parameters for using various Cloud services from Carbon Emission Directory. The Carbon Emission Directory maintains all the data related to energy efficiency of Cloud service. This data may include PUE and cooling efficiency of Cloud datacenter which is providing the service, the network cost and carbon emission rate of electricity, Green Broker calculates the carbon emission of all the Cloud providers who are offering the requested Cloud service. Then, it selects the set of services that will result in least carbon emission and buy these services on behalf users. The Green Cloud framework is designed such that it keeps track of overall energy usage of serving a user request. It relies on two main components, Carbon Emission Directory and Green Cloud offers, which keep track of energy efficiency of each Cloud provider and also give incentive to Cloud providers to make their service "Green". From user side, the Green Broker plays a crucial role in monitoring and selecting the Cloud services based on the user QoS requirements, and ensuring minimum carbon emission for serving a user. In general, a user can use Cloud to access any of these three types of services (SaaS, PaaS, and IaaS), and therefore process of serving them should also be energy efficient. In other words, from the Cloud provider side, each Cloud layer needs to be "Green" conscious.

V. CLOUD COMPUTING'S HIDDEN 'GREEN' BENEFITS

As cloud computing ramps up, it will reduce greenhouse gas emissions by 95 percent, leading to savings of more than $2.2 billion, according to a study sponsored by Microsoft Europe and the Global e-Sustainability Initiative (GeSI). Expanding cloud usage beyond the basics to large-scale information and communication technology (ICT) will scale those savings up to $1.2 trillion, GeSI says.

Researchers from Harvard University, Imperial College and Reading University explored cloud computing's impact on lowering Greenhouse Gas (GHG) in Europe, Brazil, China, Canada, and Indonesia. They claim that energy usage will drop by 11.2 TWh annually when 80 percent of public and private organizations in those regions opt to provide cloud-based email, customer relationship management (CRM) and groupware solutions to their staff, going beyond current levels of adoption. To put it in perspective, this equals 75 percent of the energy consumed by the capital region of Brussels or 25 percent of the energy consumed by London. It is equivalent to abating 4.5 million metric tons of CO2 emissions annually, the study says. And 60 percent of these potential savings relate to small firms. Cloud infrastructure outperforms on-site services and power-hungry data centers, according to lead researcher Peter Thomond. He says that for every metric ton of GHG emissions generated by a cloud vendor that provides email, CRM and groupware, 20 metric tons are reduced for its clients. The study examines both the energy savings and GHG abatement potential of cloud computing in 11 countries: Brazil, Canada, China, Czech Republic, France, Germany, Indonesia, Poland, Portugal, Sweden and the UK.

GeSI, which is a partnership of the ICT sector, says that cloud-based email and CRM is only the tip of the iceberg and large-scale broadband and information and communication technology could deliver a 16.5 percent reduction in GHGs and save up to $1.9 trillion in savings by 2020.The new Microsoft/GeSI study says vendors and governments have created hurdles to wider adoption of cloud-based services. Governments can influence wider adoption of cloud computing if they use it for their own services, although the ultimate responsibility lies with cloud vendors. More evidence of the cloud's ability to reduce GHGs and acceptance of the challenges that come with behavioral changes when shifting to the cloud will help convince the public. According to a new research from Pike

Research, the global market for green datacenters will grow from $17.1 billion in 2012 to $45.4 billion by 2016.

To be more specific to understand the real impact of the server, it is important to assess the energy source that produces electricity consumed by the storage systems, the energy efficiency of data centers and the type of equipment and devices that are used. It is also important to keep in mind that a data center has a more environmental impact than a system. The research based on five setups scenarios, on-premise with no virtualization; co-location with no virtualization; on-premise with virtualization; private cloud; and public cloud, found that on-site server with no virtualization will emit about 46kg of CO2 per year. The figure will touch 2kg if a person using a public cloud conforming to best practices. If you are storing data on the public cloud but using a public cloud provider whose servers are not that efficient, are not well used and use electricity from higher-carbon-emitting sources, there could be scenarios where running your own servers is a greener option. Overall, the study revealed that running business applications in the cloud is considered as more energy and carbon efficient than running it on-premise. While cloud computing is generally more energy and carbon efficient than on-premise server rooms, Social media optimization (SMO) looking to improve the environmental sustainability of their operations should ask cloud service providers for full disclosure of the carbon efficiency of the services they offer. Data centers that utilize Cloud technologies are more efficient than traditional data centers. Energy is usually lost though server underutilization, because most of the time these servers are just in idle mode, but in a cloud environment the system is managed to run at the highest efficiency. It would be like 80 trucks driving down the road, all driving to the same location and each carrying 1% of their capacity, instead of one truck loaded up with 80% capacity. In this scenario, the remaining 79 trucks are just wasting energy. In addition, data center planning allows better power utilization**.** In traditional data centers, there can be cooling problems and you can run out of space for more servers. There is also a consortium of cloud providers **the** Green Grid which assures that its members optimize their data centers to minimize power consumption. According to a recent Microsoft report, cloud computing can help with energy reductions through the employing of large scale virtualization. Also, software architecture can be optimized so that it provides the same functionality with less energy. Service providers in cloud computing need to keep their expenses down, so they must ensure there is no waste of energy. Their focus is on performance so they provide the maximum of services with the least resources, energy included, which ultimately results in lower costs to you, the customer. The Green Cloud framework is designed such that it keeps track of overall energy usage of serving a user request. It relies on two main components, Carbon Emission Directory and Green Cloud offers, which keep track of energy efficiency of each Cloud provider and also give incentive to Cloud providers to make their service “Green”. From user side, the Green Broker plays a crucial role in monitoring and selecting the Cloud services based on the user QoS requirements, and ensuring minimum carbon emission for serving a user. In general, a user can use Cloud to access any of these three types of services (SaaS, PaaS, and IaaS), and therefore process of serving them should also be energy efficient. In other words, from the Cloud provider side, each Cloud layer needs to be “Green” conscious. Green Computing has become an innovative way on how technology and ecology converge together. With the recent years many industries and companies have turned their attention in realizing how going 'green' can benefit public relations, reduced costs, and lowering global emissions from industrial manufacturing.

VI. NEED OF GREEN COMPUTING

The adoption of cloud computing will lead to a 38% reduction in worldwide data center energy expenditures by 2020, compared to a business as usual (BAU) scenario for data center capacity growth, according to Cloud Computing Energy Efficiency, a new report from Pike Research.

As part of its cloud computing adoption scenario, Pike Research forecasts that data centers will consume 139.8 terawatt hours (TWh) of electricity in 2020, a reduction of 31% from 201.8 (TWh) in 2010. This also represents a significant decrease from the 226.4 TWh that would be consumed by data centers in the firm’s BAU scenario. The reduction will drive total data center energy expenditures down from $23.3 billion in 2010 to $16.0 billion in 2020, as well as causing a 28% reduction in GHG emissions from 2010 levels. The idea of green computing has been around a good time, the government themselves play a role in it. For example the Environmental Protection Agency (EPA) launched the 'energy star' program in the 90s, to promote energy efficient methods. The EPA today still plays an active role by providing not only energy effective methods, but also cost effective methods for the consumers. In 2006 the EPA established a way to save U.S. households and businesses money; "With an eye to saving U.S. households and businesses more than $1.8 billion in energy costs over the next 5 years, today EPA announced new Energy Star specifications for computers and related equipment. These new modifications are also expected to prevent greenhouse gas emissions equal to the annual emissions of 2.7 million cars."(Jones, 2006) Though the EPA is a recognizable agency, they are not the only ones who promoting new ways of going green in the technological aspect. Organizations such as European Union and TCO Certification are one of the leading groups in green computing. Advancements in green computing have become vast. There are so many new ways of combining ecology with technology, that we practically are trying a bit of everything. Such as using solar technology, solar technology now is being used on keyboards and mice now to reduce energy costs. Another green computing method is eliminating certain materials that are hazardous to the environment, and replacing them with cleaner and efficient materials which are biodegradable and eco-friendly. Even now certain computer components such as processor units have reduced heat emissions, and monitors as well with their advancement of flat screens.

Not only is green computing effecting components and other various hardware, it has changed in ways businesses use technology such as cloud computing. Cloud computing essentially is a method of a user connecting to a network or server, through the internet. Ultimately this

reduces the need of businesses to have purchase more computers, which can emit greenhouse gases when left on.

The practice of green computing has essentially branched off to every form of technology out there. Cars being a great example, now with hybrids becoming mainstream, people are able to save on gas, money, and also cutting on carbon monoxide, and other various dangerous gases to the atmosphere.

Green computing has also grasped how industries market themselves, and many realize how going green in their technologies can aid them. One great example of green computing corporation is Apple. "Apple has been criticized by some environmental organizations for not being a leader in removing toxic chemicals from its new products, and for not aggressively or properly recycling its old products" (Jobs, 2009) but that has changed, when looking now upon Apple's computers, their unibody designs material is a great source to dissipate heat, along with their products being able to conserve energy very well. Not only have they implemented ways in being more eco-friendly by removing hazardous materials in their computers and products, but their manufacturing and delivering their goods has also been altered to help the environment

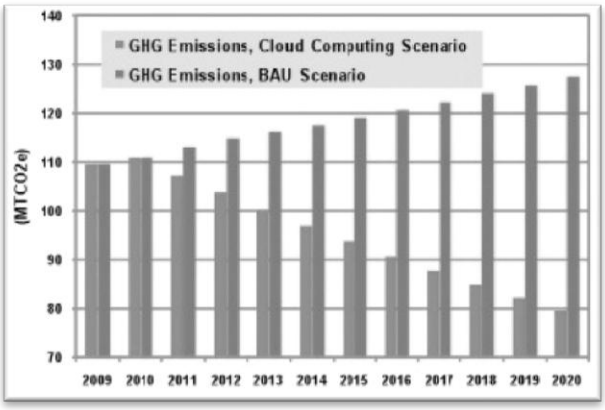

Fig. 3: Data Center GHG emissions 2009-2020

VII. CONCLUSIONS AND FUTURE DIRECTIONS

In conclusion, by simply improving the efficiency of equipment, Cloud computing cannot be claimed to be Green. What is important is to make its usage more carbon efficient both from user and provider's perspective. Cloud Providers need to reduce the electricity demand of Clouds and take major steps in using renewable energy sources rather than just looking for cost minimization. The future of cloud computing is bright for the companies that implement the technology now. While these are some trends that are expected in the future, the future is not limited to these trends. Remain abreast of the latest developments to help your company maintain a competitive advantage. This will make your company more profitable and productive when it can complete tasks faster and more efficiently than the competition.

REFERENCES

[1] Buyya, R., Yeo, C.S. and Venugopal, S. 2008. Market-oriented Cloud computing: Vision, hype, and reality for delivering it services as computing utilities. Proceedings of the 10th IEEE International Conference on High Performance Computing and Communications, Los Alamitos, CA, USA.

[2] New Datacenter Locations. 2008. http://royal.pingdom.com/2008/04/11/map-of-all-google-data-center-locations/

[3] Rivoire, S., Shah, M. A., Ranganathan, P., and Kozyrakis, C. 2007. Joulesort: a balanced energy-efficiency benchmark, Proceedings of the 2007 ACM SIGMOD International Conference on Management of Data, NY, USA.

[4] "Toward a Cloud Operating System" Fabio Pianese Peter Bosch Alessandro Duminuco Nico Janssens Thanos Stathopoulos Moritz Steiner Alcatel-Lucent Bell Labs Service Infrastructure Research Dept. Computer Systems and Security Dept.

[5] "A Unified Operating System for Clouds and Manycore" fos David Wentzlaff, Charles Gruenwald III, Nathan Beckmann, Kevin Modzelewski, Adam Belay, Lamia Youseff, Jason Miller, and Anant Agarwa CSAIL, Massachusetts Institute of Technology.

[6] Guo Bing, Shen Yan, and Shao ZL, "The Redefinition and Some Discussion of Green Computing", Chinese Journal of Computers, vol. 32, Dec. 2009, pp. 2311-2319.

[7] Greenpeace International. 2010. Make IT Green http://www.greenpeace.org/international/en/publications/reports/make-it-green-Cloudcomputing/

[8] Verma, A., Koller, R., Useche, L., and Rangaswami, R., 2010. SRCMap: energy proportional storage using dynamic consolidation. 2010, Proceedings of the 8th USENIX conference on File and storage technologies (FAST'10), San Jose, California

[9] Bianzino, P., Chaudet, C., Rossi, D., and Rougier, J. (2011). A Survey of Green Networking Research, IEEE Communications Surveys and Tutorials, IEEE, USA (in press.)

[10] Wang, D., "Meeting Green Computing Challenges," Proceeding of the International Symposium on High Density Packaging and Microsystem Integration, 2007 (HDP '07), IEEE, 2007.

[11] Wellsandt, S. and S. Snyder, "Building a Long-Term Strategy for IT Sustainability," Intel Information Technology, White paper, 12 pages,April 2009. Retrieved April 26, 2009 from http://communities.intel.com/community/openportit/it

[12] Wilbanks, L., "Green: My Favorite Color," IT Professional, pp. 63-64, November-December, 2008.

[13] Wong, H., "EPA Datacenter Study IT Equipment Feedback Summary," Intel Digital Enterprise Group, Cited in: Report to Congress on Server and Data Center Efficiency Public Law 109-431, U.S. EPA EnergyStar Program, August 2, 2007.

[14] Zarella, E., "Sustainable IT: The Case for Strategic Leadership," KPMG IT Advisory, White paper, 24 pages, 2008. www.kpmg.com.

[15] http://lacreativeweb.com/cloud-computing/5-cloud-oriented-operatingsystems-available-now

[16] Warmenhoven, D., "Three Years Later: A Look at Sarbanes-Oxley,Forbes, July 27, 2005.

[17] Sergi Figuerola, Mathieu Lemay, Victor Reijs, Michel Savoie, Bill St.Arnaud, "Converged Optical Network Infrastructures in Support of Future Internet and Grid Services using IaaS to Reduce GHG Emissions", Journal of Lightwave Technology, Vol. 27, Dec. 2009, pp.1941-1946.

