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Energy Efficient Data Centers

First International Workshop, E²DC 2012
Madrid, Spain, May 8, 2012
Revised Selected Papers

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Preface

In the last decade, energy awareness has been slowly but continuously dominating our thoughts in business and private life. In the first phase, we might have only naively switched off lights when not needed or turned off our desktop during the nights, but nowadays we are prioritizing in a more sophisticated way how we can dynamically achieve the biggest impact. One of the areas that has proven to make a difference is ICT, not only through the effect that, owing to its pervasiveness, it has on other sectors; but also because of the substantial amount of 830 MtCO₂¹ that the ICT sector itself (2007) is devouring world-wide.

Within ICT, with a share of 14%¹ at the global ICT carbon footprint (2007), data centers, while still not accounting for the lion share of consumption, are nevertheless the fastest growing sector that is estimated to increase its share by more than 25% until 2020. That observation was reason enough for us to launch the First International Workshop on Energy-Efficient Data Centers, E²DC 2012, in order to increase the international recognition of energy-aware data center technologies, fostering lively exchange of ideas and interaction among participants. It was collocated with the e-Energy conference and took place in Madrid, Spain, on May 8, 2012, and was organized by the EU FP7 FIT4Green project.

The workshop resulted in these proceedings, with a scope ranging from information and communication technologies of green data centers to business models and GreenSLA solutions. The first section presents contributions in the form of position and short papers, related to various European projects. The other two sections comprise papers with more in-depth technical details. The topics covered include energy-efficient data center management and service delivery as well as energy monitoring and optimization techniques for data centers.

The first part of the proceedings contains five papers introducing research in the context of European projects and initiatives. The papers include, for example, an overview about research relating to green service level agreement extensions to establish and improve collaboration between different actors in the data center energy provisioning ecosystem (All4Green) as well as an introduction to green performance indicator definitions and benchmarking tools for data center software and hardware (GAMES). Related to service level agreements, a new standards-based solution is introduced to dynamically create service level agreements between cloud service providers/end-users and infrastructure providers (OPTIMIS). In addition, a new advanced simulation and visualization toolkit is presented for modeling and analyzing the data center energy

¹ Webb, M. et al.: SMART 2020: Enabling the low carbon economy in the information age. The Climate Group London.

DOI: http://www.ecoc2008.org/documents/SYMPTu_Webb.pdf, 2008

efficiency (CoolEmAll). The final paper of the first part presents an implementation of benchmarking tools, which can show explicitly the energy- and cost-saving potential in data centers.

Part 2 presents four papers on energy-efficient data center management and service delivery. The topics of the papers vary from cloud computing and virtualization systems to dynamic service level agreement based, or SLA-based, server hardware management and GreenSLA management. For example, Drzen Lucanin et al. consider an emission trading market and decision model for a greenhouse gas trading system for data centers, whereas the paper of Vlasia Anagnostopoulou concentrates on the SLA-based resource management for resource-demanding Internet services. Marco Guazzone et al. introduce a virtual machine migration-based concept for system-level energy consumption minimization for infrastructure-as-a-service (IAAS) cloud systems. In their contribution on data center management, Christian Bunse et al. suggest utilizing GreenSLAs for the energy optimization and system control from a service provider point of view.

Part 3 on “Data Center Energy Monitoring and Optimization” provides insight into more focused solutions to monitor and measure data center services. One main aspect is the data center federation, in which data center services are distributed in geographically different locations, also utilizing various energy and cooling sources with different emission characteristics. Mikko Pervilä et al. present in their paper a low-cost and quick way to model a data center’s air flow and temperature characteristics, without extensive and resource-demanding simulations. Edward Curry et al. suggest an environmental charge-back model, which can be used for indicating the data center’s environmental impact directly to consumers. The contribution by Dang Ming Quan et al. addresses energy optimizing opportunities of a data center federation and proposes a new resource optimization algorithm to minimize the power consumption and carbon dioxide emissions in a federated data center scenario. Using a bionic approach, Ghislain Chetsa et al. present a DNA-inspired energy consumption optimization model for high-performance computing systems.

In total, 32 papers related to energy efficiency aspects of data centers were submitted, 13 of which were selected through a peer-reviewed process for publication in these proceedings. The workshop also included three additional presentations: The FIT4Green project approach by Giovanni Giuliani (HP Italy Innovation Centre, Italy), the keynote speech by Marta Chinnici (ENEA, Italian National Agency for New Technology, Italy), and a presentation about a new energy-efficient data center facility initiative, which targets to re-utilize the unused paper mill facilities in Nordic countries, by Kimmo Koski.

We would like to thank all authors for their contributions to this volume and in particular the reviewers for their hard work which significantly helped to improve the initial submissions and made our work easier when selecting the papers. We would like to also thank all volunteers who shared their talent, dedication, and time for the workshop arrangements and for preparing these proceedings: Special thanks are extended to the e-Energy 2012 Organizing Committee and

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Last but not least, we are grateful for the strong support from the European Commission and the ICT FP7 FIT4Green project, especially from Maria Pérez Ortega (GFI, Spain) and Giovanni Giuliani (HP Italy Innovation Centre, Italy).

May 2012

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