GUEST EDITORIAL PREFACE

Second Special Issue on Green Networking and Computing

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Optimization and reduction of energy consumption and the environmental impact of greenhouse gas emissions are among the most urgent challenges of the twenty-first century. Such challenges call for significant research to be carried out in order to develop new technologies that can enable a transition towards a more energy efficient society, leading to a reduced carbon footprint. Information and communication technologies (ICT) can reduce the environmental impact of human activities by improving energy efficiency in many sectors of the world's economies. However, recent studies indicate that global ICT energy consumption amounts to 7 percent of entire electricity production, which in turn causes about 2 percent of the world's carbon dioxide emissions. Due to the rapid growth of traffic and infrastructure, energy costs of communications networks as typically representative of ICT sector become significant. Studies show that network equipment in wired networks consume 15 percent while base stations in cellular networks up to 80 percent of overall energy used. Due to this, energy efficient and sustainable networking and computing, often simply referred to as "Green networking and computing", have gained huge attention by researchers in academia and industry over the last few years.

To meet the challenges of increasing energy efficiency in networking and computing, it is necessary to develop and implement diverse paradigm-shifting technologies such as: energy-efficient cooperative techniques among mobile network operators, energy-efficient networking devices, energy-efficient virtualization models, and power supply systems based on renewable energy sources. All of these technologies have been discussed in this second special issue on green networking and computing, which is a continuation of the previous Volume 9 issue (April-June 2013) of the *International Journal of Business Data Communications and Networking* (IJBDCN). It includes four articles selected for publication, which are dedicated to the latest advances in energy-efficient fixed and mobile communication technologies.

The first article, "A Game Theoretic Approach to Guarantee Fairness in Cooperation among Green Mobile Network Operators" by Militano, Molinaro, Iera, and Petkovics, considers cooperation between cellular network

operators as an effective way to reduce carbon dioxide (CO_2) emissions and, simultaneously, operating expenditures (OPEX) of the providers. In order to make such a solution more attractive in real implementation scenarios where profit-driven network providers act as rational players, the authors propose a game theoretic approach in order to introduce fairness and stability into an optimal algorithm for switching off the base stations belonging to cooperative mobile operators. This is accomplished through implementation of the transferable utility game model. The authors studied the proposed game model and compared the cost/savings allocations obtained with the optimal solution and two well-known game theoretic cost allocations, namely the Nucleolus and the Shapley-value. According to the obtained results, the game theoretic solutions offer a fairer distribution of the costs/savings among the cooperating operators, with all network providers gaining some benefits from the cooperative approach. In addition, the proposed solution guarantees stable allocations in the sense that all players have a personal advantage and are interested in being part of the coalition. Since these features are not guaranteed with the optimal cost allocation, it is reasonable to believe that the proposed model will help in driving the application of cellular network cooperation in real scenarios.

In the second article, "Design of a Temperature-Constrained Governor to Save Energy in an Open Multi-Frequency Green Router" by Lombardo, Reforgiato, Riccobene, and Schembra, a governor policy for a green router that provides the best trade-off between quality of service and energy-saving in respect of a given target working temperature is proposed. The idea behind this is to encourage the development of so-called "green routers" able to enter different power states according to the input traffic. Reducing the average operating temperature of such green routers through the application of algorithms aimed at reducing energy consumption will allow designers to modify hardware, reducing its size and the size of the passive and active cooling systems. The authors perform analyses to evaluate the performance of such a router regarding the proposed "green" clock frequency management scheme and design of the switching probability set used for switching the clock frequency according to the bit rate of incoming traffic. The simulations carried out show that green router designers can control the temperature statistics of a router through the use of real traffic traces and the energy saving law applied by the router governor. This enables the manufacturers to evaluate the energy-saving gain at a specific working temperature. In addition, the case study performed has shown how analysis can be used to design the router governor parameters to achieve the target of maintaining the mean temperature below a given threshold.

The third article of the this second special issue on green networking and computing, "Optimal Green Virtual Machine Migration Model", by Sabri, addresses an optimization view of the problem of locating a set of cloud services among green data centre sites managed by a service provider. Since energy consumption is a key aspect in deploying distributed service in cloud networks within decentralized architectures, goal of the presented research was to minimize the overall network energy consumption and carbon emissions for accessing the cloud services for any pair of data centers. Hence, paper proposes an optimization model dedicated to optimal placement of virtual machines with consideration of green energy resource availability. Proposed optimization model is developed using integer linear programming and optimizes the data access by placing the virtual machines on the nearest data centers with the smallest data transfer time. In comparison to the random migration strategy, the experiments demonstrate the significance of optimization for improving network energy-efficiency. Hence, proposed "green" optimizer enables energy-efficient VMs migration across all data centers in the cloud environment.

Last article of this special issue is research essay, "Renewable energy sources for power supply of base station sites", by Lorincz and Bule. Article gives an overview of research activity in the area of powering base station sites

by means of renewable energy sources. Since base stations are major consumers of cellular networks energy with significant contribution to operational expenditures, powering base stations sites using the energy of wind, sun, fuel cells or a combination gain mobile operators' attention. Hence, technical descriptions of the various power supply systems based on renewable sources with corresponding energy controllers for scheduling the flow of energy to power base station sites are discussed. Authors pointed out that configuration of a hybrid or standalone power supply system based on renewable energy sources depends on the cost of installation and operation of the system, availability of renewable energy sources, and load generated by equipment installed at the BS site. It is shown that powering base station sites with such renewable energy sources can significantly reduce energy costs and improve the energy efficiency of the base station sites in rural areas. Also, it is emphasized that in the areas having satisfactory level of renewable energy, it is possible without support of diesel generator to use standalone or hybrid power supply system for continuous powering of BS site during whole year. Paper concludes emphasizing that in rural and remote areas, it is expected that further trends will transform off-gird diesel powered BS sites into green and sustainable ones powered by renewable energy sources.

We hope that the selected articles in this second special issue will further encourage the readers of the IJBDCN journal to be actively involved in this significant engineering area of green networking and computing. Finally, we would like to thank all of the authors who submitted articles to this special issue and to the reviewers for their comments and valuable feedback on the submitted articles.

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Guest Editor
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Josip Lorincz received a B.Sc. (M.S. equivalent) degree in electrical engineering from the University of Split, FESB, Croatia in 2002. In 2003 he joined the Department of Electronics at FESB – Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture, University of Split, Croatia. He was a visiting researcher at the Advanced Network Technologies Laboratory (ANTLab) of the Politecnico di Milano, Milan, Italy. In July 2010 he obtained a Ph.D. degree in telecommunications engineering and computer science from the University of Split, FESB, Croatia. He is co-chair of Symposium on Green Networking and Computing, organized in the frame of International Conference on Software, Telecommunications and Computer Networks (SoftCOM). He also serves as the technical program committee member for many international scientific conferences. He was awarded as outstanding young researcher by the Croatian Academy of Engineering in 2013. His current research interests include energy-efficient wireless and wired networks, optimization in telecommunications, advanced design, the management and analyses of computer heterogeneous networks, and performance evolution of routing protocols. He is a member of IEEE, ACM, and the Mathematical Optimization Society. Since 2004, he has owned Cisco CCNA, CCAI, and BCMSN certificates.