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Green Communications and Networking

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The worldwide growing energy demands together with the increasing depletion of fossil fuels have been recognized as a major challenge that needs to be urgently addressed by society in order to have a sustainable future. To investigate new technologies that can enable a transition towards a more sustainable society with a reduced carbon footprint is of prime importance. It is well understood that ICT is one of the keys to a future low-carbon and sustainable society. Communications technologies will be critical to achieving large-scale energy savings in all domains including communications, manufacturing, transportation, buildings, and electricity generation and distribution. In this context, there is a critical need for new ways of reducing energy consumption of communication and networking systems if the current trajectory of traffic growth and supporting anywhere/anytime/anything access is to continue unabated. Energy costs are significant in a broad range of communications networks ranging from data center networks (where network equipment consume about 15 % of the overall energy used) to cellular networks (where energy use of base stations amounts to around 70 % of the total). The need for 'greener' communications and networking technologies has been recognized by the research community as demonstrated by the significant research efforts in this area during the last years. However, many challenges still remain to be addressed.

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This special issue has been focused on recent research results in the area of green communications and networking. It has solicited original, unpublished research papers both from academy and industry reporting on substantial results in the green communications and networking area enabling significant future energy savings. It includes twelve selected papers with high quality from the conference GreenNets 2014, which was held in Xi'An, China, August 26–28, 2014. The special issue received 46 submissions. After a conscientious review process, we had an acceptance ratio of 26 %. Next we present the papers accepted as October 2015 MONET Special Issue.

This first article, "Hybrid Placement of Internet Gateways and Rechargeable Routers with Guaranteed QoS for Green Wireless Mesh Networks", co-authored by Bang Wang and Xiaoli Huan, considers the node placement and energy management in a hybrid WMN consisting of electricity-powered Internet gateways and solar powered rechargeable routers and introduces a new metric of failure rate to evaluate network performance and formulate the problem as a constrained optimization problem with the objective of minimizing both capital expenses on installation and operational expenses related to energy consumption. In order to connect mesh clients to the Internet in different slots, the author proposed a minimum cost association algorithm and a greedy placement algorithm to find approximate solutions for hybrid node placement. Simulation results show that the hybrid placement with rechargeable routers reveals its advantage for large scale networks in terms of more energy saving. Compared with the optimal placement achieved by the exhaustive search, the proposed algorithm can achieve good performance with the significantly reduced computation complexity.

The second article titled "Service-Oriented Virtual Machine Placement Optimization for Green Data Center" from Fan-Hsun Tseng, Chi-Yuan Chen, Li-Der Chou, Han-Chieh Chao, Jian-Wei Niu, designed the first service-oriented virtual

machine (VM) placement for green data center basing Integer Linear Programming (ILP). The Tree algorithm is proposed to place VM role instances at the lowest communication cost, economizing the construction cost with fewer physical servers while nother Forest algorithm is proposed for balancing the computation load between the physical machines, both formulating on the graph theoretic technique and evaluated and analyzed using the Best Fit algorithm in the simulations with total power consumption and average utility slightly impaired. The results show that the proposed Tree and Forest algorithms provide lower communication cost than the Best Fit algorithm, and achieve green communications for large scale environment such as cloud or green data center.

The next article investigates energy efficient management for wireless mesh networks with green routers. The authors (Sarra Mamechaoui, Sidi Mohammed Senouci, Fedoua Didi and Guy Pujolle) proposed an optimal approach called Optimal Energy Efficiency Management Design (OEEMD) by formulating the problem as a Mixed Integer Linear Program (MILP) model to investigate the power consumption in WMN, and an efficient heuristic algorithm called Green Energy Efficiency Management Design (GEEMD) for wireless mesh networks. Illustrative numerical examples show that, with suitable design parameters, the energy consumption can be efficiently reduced in WMN without significantly impacting the network performance. The Green Energy Efficiency Management Design techniques applied on WMN can be generalized so that they are also applicable to other access networks.

The fourth article, "An Energy-efficiency Node Scheduling Game Based on Task Prediction in WSNs" from Kai Lin, Tianlang Xu, Mohammad Mehedi Hassan, Atif Alamri, Abdulhameed Alelaiwi, discusses how to schedule the sensor nodes to sleep or wakeup according to the dynamically changing task load, in which the unbalanced task load will dramatically reduce the network lifetime for resource constrained WSNs. It is demonstrated that for a sensor network with uniform node distribution and constant data reporting, balancing the task load of the whole network cannot be realized. By designing a state transition model for sensor nodes and introducing Markov chain, the author proposed a task prediction method to predict the local task load in the next time period, as well as an energy-efficiency node scheduling algorithm based on game theory (ENSG) for WSNs. The simulation results show that ENSG can guarantee the real-time task completion and prolong the lifetime of network.

The fifth article, "A Game Theoretical Model for Energy-Aware DTN Routing in MANETs with Nodes' Selfishness" from Yuxin Mao, Ping Zhu, the author presented an incentive mechanism for encourage forwarding cooperation during energy-aware routing in MANETs in this paper and argued that the node selfishness in relay cooperation will influence the overall performance of routing in MANETs. After trying to explore the game theory to model the situation of energy-aware DTN routing in MANETs with nodes' selfishness and considering the competitive and cooperative relationships between the nodes in MANET as a simultaneous game and give the corresponding game theoretical formulation in detail, the author conducted a simulation for the proposed method and give detailed analysis, thus being able to get an equilibrium of evolutionary stable strategies through the simulation. The author proved itself to be able to enable a MANET to support more efficient energy-aware routing by configuring suitable parameters according to the results of simulation.

The sixth article, "BTDGS: Binary-Tree based Data Gathering Scheme with Mobile Sink for Wireless Multimedia Sensor Networks" from Chuan Zhu, Hui Zhang, Guangjie Han, Lei Shu, Joel J.P.C Rodrigues, basing on a virtual binary-tree infrastructure, a novel energy efficient data gathering scheme with a mobile sink for WMSNs, BTDGS is proposed. The author first presented an adaptive rendezvousbased data gathering scheme for WMSNs with a single mobile sink, an adaptive marked-area data gathering scheme, in which the rendezvous area changes with the location of sink changes to avoid the rendezvous area become a new 'hot spot'. Then, an improved data gathering scheme BTDGS is proposed to further reduce the scope of broadcasting sink location by introducing the DirS value, thus reducing the energy consumption. The main contribution of the proposed data gathering scheme is energy efficient collecting the whole network data with less broadcast overhead, with the simulation results showing that BTDGS is an energy effective, reliable, timely, and sojourn time adaptive data gathering scheme as well as feasible and suitable for WMSNs.

The seventh article, "A Green Approach for Sel_sh Misbehavior Detection in 802.11-Based Wireless Networks" from Thaier Hayajneh, Ghada Almashaqbeh, Sana Ullah, the author proposed a green solution for selfish misbehavior detection in IEEE 802.11-based wireless networks that works in two phases: Global phase which detects whether the network contains selfish nodes or not, and Local phase which identifies which node or nodes within the network are selfish. The solution is green in the sense that it saves the network resources as it avoids wasting the nodes energy by examining all the individual nodes of being selfish when it is not necessary while the proposed detection algorithm is evaluated using extensive OPNET simulations. The results show that the Global network metric clearly indicates the existence of a selfish node while the Local nodes metric successfully identified the selfish node(s).

The eighth article, "Joint Power Allocation and Routing in Outage Constrained Cognitive Radio Ad Hoc Networks" from Surajit Basak, Tamaghna Acharya, the author obtained corresponding routing metrics to solve the routing problems after studying both minimum total interference(MTI) and maximum lifetime (ML) routing problems separately as joint

power allocation and routing problems. Closed form expression for a hybrid-ML-MTI power allocation approach is proposed followed by a new hybrid routing metric with implementation issues related to the proposed hybrid routing and power allocation scheme being presented. Extensive simulation results show that while in grid networks, a straightforward combination of MTI routing with ML power allocation scheme strikes a good balance between interference and lifetime performances, in random networks, proving the proposed hybrid approach is found to extend lifetime and control interference performances simultaneously in a significant manner.

The ninth article, "ME-ContikiMAC: An Energy Efficient Protocol for Bursty Traffic in Mobile WSNs" from Georgios Z. Papadopoulos, Vasileios Kotsiouy, Antoine Gallais, Periklis Chatzimisios and Thomas No¨el, the author investigated preamble-sampling solutions that allow asynchronous operation and introduce anycast transmission to ContikiMAC where a mobile node emits an anycast data packet whose first acknowledging node will serve as responsible to forward it towards the sink. The author proposed Mobility-Enhanced ContikiMAC (ME-ContikiMAC), a protocol that reduces packet duplications in the network by more than 90 % comparing to MContikiMAC after demonstrating that even a basic anycast-based M-ContikiMAC would fail to handle bursty traffic from mobile nodes mainly due to increased unnecessary traffic and channel occupancy, with the results in a 48-node scenario showing that ME-ContikiMAC outperforms a number of state-of-the-art solutions (including MoX-MAC and MOBINET), by terms of reducing both delay and energy consumption.

The tenth article, "A Novel Energy-saving One-Sided Synchronous Two-Way Ranging Algorithm for Vehicular Positioning" from Jianqi Liu, Jiafu Wan, Qinruo Wang, Di Li, Yupeng Qiao and Hu Cai, after analyzing the pros and cons of representative algorithm of vehicular positioning, such as Symmetric Double Side-Two way Ranging (SDS-TWR), the author utilized the RSUs to server as anchor to offer location reference and proposed a novel energy-saving One-Sided Synchronous Two-Way Ranging (OSS-TWR) algorithm to reduce the communication times(the overhead of communication network), which gains lower energy consumption and better performance than SDS-TWR.

The eleventh article, "Improving Energy-efficiency with a Green Cognitive Algorithm to Overcome Weather's Impact in 2.4 GHz Wireless Networks" from Diana Bri, Miguel Garcia, Francisco Ramos, Jaime Lloret, proposed a green cognitive algorithm that adapts wireless transmissions to the channel conditions caused by the weather while focusing on a solution to enhance the energy efficiency in outdoor wireless local area networks using the standard IEEE 802.11b/g. By showing the weather's impact on outdoor networks from a statistical analysis performed over an experimental setup composed of an outdoor point-to-multipoint link, the author proved that the number of control frame errors and retransmissions at MAC layer is related to the power consumption and proposed a new green cognitive algorithm to overcome the weather's impact and to enhance the energy efficiency as a good option for outdoors WLANs.

In this last article with the title "An Energy Saving Strategy for LTE-A Multiantenna Systems", the authors (Reema Imran, Mutaz Shukair, Nizar Zorba and Christos Verikoukis) proposed a novel energy efficient MAC scheme for LTE-A, which aims to achieve simultaneous downlink transmissions to multiple users, through the deployment of a low complexity beamforming technique at the physical layer. The author first discussed a new energy efficient MAC scheme that supports MU-MIMO transmission, which is combined with MOB and AMC at the physical layer. By exploiting AMC to apply energy saving mechanism at the transmitter without causing any degradation in the system performance, while being back-compatible with the LTE-A specs, the author formulates both the energy saving and throughput of its proposal through closed form expressions that match the computer-based simulations where the results from the proposed scheme achieve a considerable energy saving at the Base Station (eNB). Moreover, its proposed scheme takes advantage from the multiuser gain of the MIMO channel and the multiplexing gain of the Multibeam Opportunistic Beamforming (MOB) technique, to improve the system throughput and the energy efficiency of wireless networks.

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