Advances in Green Mobile Networks

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Global warming and climate change have been a growing worldwide concern. Six sources, i.e., transportation, power, buildings, industry, agriculture and forestry, and land use, have been identified as major contributors to the rise of global carbon dioxide (CO₂) emission from 40 giga-tonnes of CO₂ equivalent (Gt CO₂e) in 2002 to an estimate of 52 Gt CO₂e in 2020. The mobile industry is seen as a potential enabler to reduce greenhouse gases contributed by these six sources provided that appropriate measures are implemented. On the other hand, the mobile industry itself will also contribute to CO₂ emission through network operations, mobile equipments, etc. To meet the requirement of low-carbon economy development, it is necessary to reduce the operation expenditure or energy consumption of mobile networks, while maintaining acceptable quality of service. This special issue is intended to provide a forum for presenting, exchanging and discussing the recent advances on green mobile networks in terms of system architectures, networking & communication protocols, applications, tested and prototype, traffic balance and energy-efficient cooperation transmission. In response to the call for

contributions, we have received 52 paper submissions from both academia and industries that covered a variety of interesting topics. Two rounds of careful review by the guest editors and experts in the field led to 13 papers for inclusion in this issue.

The first paper “A Survey of Green Mobile Networks: Opportunities and Challenges” by X. Wang et al. extensively surveyed various remarkable techniques toward green mobile networks (mainly targeting cellular networks). The survey discussed recent energy-efficient work from the perspective of the structure of mobile networks, ranging from the data center, core backhaul, macrocell, femtocell, end-hosts, application and services. Also it summarized the current research projects related to green mobile networks, along with the taxonomy of energy-efficiency metrics (green metrics). Finally, potential future research opportunities and design challenges for green mobile networks were discussed and elaborated in this survey paper.

The second paper entitled by “ARIVU: Making Networked Mobile Games Green” by B. Anand et al. proposed an adaptive middleware that uses set of novel techniques and algorithms to conserve energy consumed by wireless interface, display and processor of mobile devices without affecting the quality of game play. With the advent of feature rich Smartphone platforms, growth rate of global smart phone sales escalates in two-digit figures in recent years. The amount of resources required in a mobile device is application dependent. Multiplayer Mobile games, one of the most downloaded applications, demand resources at their peak levels due to their interactive nature. The middleware described in the paper optimises the use of wireless resources according to demand by predicting the game state and saves up to 60% of total energy consumed by the wireless interface which translates to saving 27% of overall system energy.

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The mobile network equipped multi-antenna and orthogonal frequency division multiplexing (OFDM) technologies are widely accepted to improve the transmission rate in next generation broadband mobile communication systems. Though the technologies can greatly improve the transmission rates, it also increases the transmission power caused by the multi-antenna system. To solve these problems, some theory research and application technologies, such as energy-efficiency network architecture and protocols, interference modelling, cooperation architecture among base stations, cross-layer energy-efficiency optimization, traffic balance and energy-efficient cooperation transmission should be investigated to satisfy future requirements from green mobile networks. In the paper “Energy Efficiency Analysis of MISO-OFDM Communication Systems Considering Power and Capacity Constraints”, X. Ge et al. use the power and capacity constraints to formulate and solve an optimization problem modeling the power allocation for a MISO-OFDM communication system. The major idea behind the proposed approach is to adapt the multi-variables constraints in a model to trade off different performance requirements. The simulation results show that there is a minimum sub-channel capacity threshold to impact on energy efficiency and total capacity of MISO-OFDM communication systems.

In the paper “Energy-Efficient Resource Allocation in Mobile Networks with Distributed Antenna Transmission” by L. Zhong et al., distributed antennas are used with proposed cooperative transmission algorithm to improve the energy efficiency, which is crucial in green mobile networks. The major idea behind the proposed approach is to reduce the energy wasted in the propagation stage through multiple and distributed antenna transmission and maximize the energy efficiency through resource allocation. The simulation results show that the presented approach achieves higher energy efficiency in regions with high operational throughput than traditional ones. In the paper “Multicarrier-Based QAPM Modulation System for the Low Power Consumption and High Data Rates” by J. Choi et al., a novel QAPM modulation method is proposed to improve the energy efficiency of the system which is a combination of QAPM and OFDM using subcarrier mapping in frequency domain. The simulation results show that the present approach achieves higher energy efficiency with a robust multi-path channel property. In the paper “Power-Efficient Spatial Reusable Channel Assignment Scheme in WLAN Mesh Networks” by R. Zhu et al., a power-efficient spatial reusable channel assignment scheme is proposed to improve quality of service of real-time traffic in green wireless mesh networks. The major idea behind the proposed approach is to mitigate the cochannel interference by adjusting the channel and power level of each radio so as to increase the opportunity of channel spatial reusability. In the paper entitled by “Energy-Efficient Spectrum Discovery for Cognitive

Radio Green Networks”, Y. Liu et al. propose a new Time-Division Energy Efficient (TDEE) sensing scheme to significantly reduce the power consumption in cognitive radio networks. The main idea is to divide the sensing period into an optimal number of timeslots and each secondary user is assigned to detect a different channel in one time-slot. An important advantage of TDEE is that the SUs do not need to exchange the control messages for the acknowledgement of a successful cooperation, leading to substantial energy saving without compromising sensing accuracy. Avoiding malicious energy consumption by insider attack is a challenging issue in green mobile networks. The paper “Energy Efficiency Routing with Node compromised Resistance in Wireless Sensor Networks” by K. Lin et al., use Ant Colony Optimization to guarantee the energy efficiency when the inside attack occurs. The major idea behind the proposed approach is to establish energy efficient and security routing by detected and avoided the compromised node. The experimental results show that the presented method can bypass most compromised nodes in the transmission path and has high performance in energy efficiency. In the paper “Mobility-assisted Node Localization based on TOA Measurements without Time Synchronization in Wireless Sensor Networks” by H. Chen et al., localization algorithms are proposed in mobile anchor assisted sensor networks.

Green mobile networks seek a reduction in the energy consumption of mobile devices, where the limitation of energy availability has become one of the most critical issues in multi-hop wireless networks, and it motivates extensive research efforts towards power-efficient routing and topology control. In the paper “Diverse Path Routing with Interference and Reusability Consideration in Wireless Mesh Networks” by F. Kandah et al., the authors propose a multipath routing (primary and protection paths) scheme for dynamic network traffic. Two major ideas lie behind the proposed scheme. First is, avoiding the use of interfered paths at the same time, which results in a bandwidth improvement where users can use their device’s energy in a more efficient way. Second is, the reusability of the protection links to reduce the energy consumption in the network, i.e., using a single path multiple times will consume energy from a small number of nodes, as well as increasing the number of free links in the network, where the nodes on those links can be put into sleep mode for energy saving purposes. X. Liu et al., in the paper entitled by “Low-cost H.264/AVC Inter Frame Mode Decision Algorithm for Mobile Communication Systems”, present a low-cost Inter frame mode decision algorithm for H.264/AVC encoder to reduce the computational complexity and energy consumption of the original encoding procedure.

In the paper “Self Organized Network Management Functions for Energy Efficient Cellular Urban Infrastructures” by K. Samdanis et al., multi-base-station cooperative

energy-efficient methods and algorithms are elaborated, with the objective to manage the energy expenditure of base stations under off-peak traffic conditions using load balancing and traffic aggregation techniques. The network-level energy management concept of energy partition, an association of powered-on and powered-off BSs, is introduced to match the capacity offered by operators to the actual demand providing the means to perform energy aware network re-configuration, which flexibly re-act to load variations minimizing energy expenditure. In the paper “An Intercommunication Home Energy Management System with Appliance Recognition in Home Network” Y. Lai et al., an intercommunication appliance management system was proposed to recognize electric appliances in home networks, which uses sensing devices that measure current to calculate the power consumption of the appliances. The system will set the characteristics and categories of each electric appliance, and then uses the classifications of the electronic energy features in order to recognize different appliances. In the paper “Energy-efficient mobile data uploading from high-speed trains” by X. Ma et al., the authors propose a novel energy-efficient scheduling approach for uploading data from cell phones in the high-speed train scenario. Energy consumption is a key issue in green mobile networks and the proposed method utilizes the unique spatial-temporal characteristics of wireless signals along high-speed railways to reduce the power consumption for uploading data. Performance evaluation demonstrates the effectiveness of this approach.

In the last paper entitled by “Power savings in packet networks via optimised routing”, E. Gelenbe and C. Morfopoulou examine the use of a gradient-based algorithm for Quality of Service and power minimisation in wired networks to result on reduced energy consumption. Two distinct schemes, conventional shortest-path routing and an autonomous algorithm energy aware routing algorithm are investigated as the starting point for the gradient algorithm. Comparisons are conducted using the same network test-bed and identical network traffic under conditions where routers and link drivers are always kept on so as to meet the needs for network reliability in the presence of possible failures and unexpected overload.

We would like to thank all the reviewers for their efforts and constructive comments. We would in particular like to thank Professor Imrich Chlamtac, the Editor-in-Chief, for his support and helpful suggestions during the very delicate stages of concluding the special issue. Finally, we would like to thank all the authors who submitted their precious research work to this special issue.

Advances in Green Mobile Networks—Paper List

1. Xiaofei Wang, Athanasios V. Vasilakos, Min Chen, Yunhao Liu, Ted “Taekyoung” Kwon, “A Survey of Green Mobile Networks: Opportunities and Challenges”
2. Bhojan Anand, Akhihebbal L. Ananda, Mun Choon Chan, Rajesh Krishna Balan, “ARIVU: Making Networked Mobile Games Green”
3. Xiaohu Ge, Jinzhong Hu, Cheng-Xiang Wang, Chan-Hyun Youn, Jing Zhang, Xi Yang, “Energy Efficiency Analysis of MISO-OFDM Communication Systems Considering Power and Capacity Constraints”
4. Lei Zhong, Yusheng Ji, Kun Yang, “Energy-Efficient Resource Allocation in Mobile Networks with Distributed Antenna Transmission”
5. Jae-Hoon Choi, Heung-Gyoon Ryu, Xuedong Liang, “Multicarrier-Based QAPM Modulation System for the Low Power Consumption and High Data Rates”
6. Rongbo Zhu, Jiangqing Wang, “Power-Efficient Spatial Reusable Channel Assignment Scheme in WLAN Mesh Networks”
7. Yi Liu, Shengli Xie, Yan Zhang, Rong Yu, Victor C. M. Leung, “Energy-Efficient Spectrum Discovery for Cognitive Radio Green Networks”
8. Kai Lin, Chin-Feng Lai, Xiangang Liu, Xin Guan, “Energy Efficiency Routing with Node Compromised Resistance in Wireless Sensor Networks”
9. Hongyang Chen, Bin Liu, Pei Huang, Junli Liang, Yu Gu, “Mobility-Assisted Node Localization Based on TOA Measurements Without Time Synchronization in Wireless Sensor Networks”
10. Farah Kandah, Weiye Zhang, Chonggang Wang, Juan Li, “Diverse Path Routing with Interference and Reusability Consideration in Wireless Mesh Networks”
11. Xingang Liu, Kwanghoon Sohn, Meikang Qiu, Minh Jo, Hoh Peter In, “Low-cost H.264/AVC Inter Frame Mode Decision Algorithm for Mobile Communication Systems”
12. Konstantinos Samdanis, Tarik Taleb, Dirk Kutscher, Marcus Brunner, “Self Organized Network Management Functions for Energy Efficient Cellular Urban”
13. Ying-Xun Lai, Joel Rodrigues, Yueh-Min Huang, Hong-Gang Wang, Chin-Feng Lai, “An Intercommunication Home Energy Management System with Appliance Recognition in Home Network”
14. Xiaoqiang Ma, Jiangchuan Liu, Hongbo Jiang, “Energy-efficient Mobile Data Uploading from High-speed Trains”
15. Erol Gelenbe, Christina Morfopoulou, “Power Savings in Packet Networks via Optimised Routing”