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Guest Editorial

Special Issue: Modeling and performance evaluation of radio resource QoS for next-generation wireless and mobile networks

By W. Li, D. Hong, D. Kazakos and L. C. Wang, Guest Editors

Next generation wireless and mobile communication systems are rapidly evolving to satisfy the demands of various network users. Due to the great success and enormous impact of IP networks, high-speed transmission is now possible for both indoor and outdoor wireless systems, internet access and web browsing have become the ruling paradigm for the next generation systems. It is envisioned that new generation wireless networks and hand-held terminals will support a wide variety of multimedia services such as multimedia web browsing, video and news on demand, mobile office system, stock market information, and so on, to mobile users anywhere, anytime in an uninterrupted and seamless way with low-powered handsets. The characteristics of wireless links, as well as the desire to maintain connectivity while on the move, offer significant challenges to provisioning quality of service and the related performance is of central interest. Since the resources (such as time, frequency and code) in the wireless segments of such networks are very limited, over-dimensioning the network resource is equivalent to poor capital investment, while congestion at busy hours could mean lost calls and lost revenues. It is therefore critical for wireless network designers to utilize these resources efficiently and effectively.

In response to the above demand for next generation wireless and mobile communication systems, this special issue aims at providing a timely and concise reference of the current activities and findings in the relevant technical fields. The primary goal is to address the key technical issues pertaining to the integrated new systems and present novel technical contributions. Ten papers are selected for publication in this special issue from over 50 submissions. Each paper was reviewed carefully by at least two reviewers. The reviewers' reports not only correct some deficiencies of the submissions but also greatly improve the quality of this special issue. We believe that all of these papers not only provide novel ideas, new analytical models, simulation and experimental results, and handful experience in this field, but also simulate the future research activities in the area of resource allocation strategies in next generation wireless networks. A brief summary of each paper is listed as follows.

The first paper by Y. Fang presents a survey on a new analytical approach his research team have developed in the last few years to evaluate the performance of wireless cellular networks under more realistic assumptions. This approach is particularly applied to the analysis of call connection performance and mobility management under assumptions that many time variables such as call holding time, cell residence time, channel holding time, registration area (RA) residence time and inter-service time are assumed to be generally distributed, and show how to obtain more general analytical results.

The second paper by A. Jamalipour, V. Mirchandani, and M. Kibria first reviews some of the state of art techniques in the area of QoS and resource management based mobility. They then propose an augmented 4G/B3G architecture that addresses key limitations in the salient 4G architectures examined in the literature. Their proposed novel augmentations in mobility, QoS, and resource management schemes consolidate operation of the 4G architecture. The other defining attributes of their proposed 4G architecture are that it is open, hierarchical, layered, and modular with cross-layer coordination and distributed network functionalities.

The third paper by S. Wang and Y. Lin describes NCTUns, an innovative network simulator and emulator for wireless and mobile networks. Effects of various radio resource management and quality of service (QoS) schemes on higher-layer protocols and real-world applications can be easily studied using NCTUns. In this paper, they elaborate on NCTUns simulation methodology, architecture, design, functionalities, performance, and applications. NCTUns simulation for wireless ad hoc, sensor, intervehicle communication networks, GPRS cellular networks, and wireless mesh networks are also illustrated.

The fourth paper by J. Misic and V. Misic analyzes the performance of E-limited scheduling in Bluetooth piconets under bursty traffic finite buffer case. They model joint probability distributions of uplink and downlink queues using the $M[x]/G/1/K$ model with vacations and derive buffer blocking probabilities at slaves and at the master. They also derive access delays at slave uplink buffers. Analytical results are illustrated through simulations, which provide some practical guidelines as to the sizing of device buffers.

The fifth paper by Y. Li, M. Thai, F. Wang, C. Yi, P. Wan, and D. Du proposes a new greedy algorithm, called S-MIS, with the help of Steiner tree that can construct a CDS within a factor of $4.8 + \ln 5$ from the optimal solution. They also introduce the distributed version of this algorithm. The authors prove that the proposed algorithm is better than the current best performance ratio, which is 6.8. A simulation is conducted to compare S-MIS with its variation, which is rS-MIS. The simulation shows that the sizes of the CDSs generated by SMIS and rS-MIS are almost the same.

The sixth paper by J. Tang, G. Xue, and C. Chandler studies the BANDwidth guaranteed Routing and timeslot Allocation (BANDRA) in TDMA-based multihop wireless networks with dynamic traffic. The authors formally model BANDRA as an optimization problem and present an integer linear programming (ILP) formulation to provide optimal solutions. This problem turns out to be a hard problem because of the impact of interference. They then propose a two-step scheme, i.e., seeking a path for routing first and then allocating bandwidth along the found path. They also present two routing algorithms to compute interference-optimal cost-bounded paths. In addition, we present an optimal bandwidth allocation algorithm to allocate timeslots along the found paths for connection requests with unit bandwidth requirements. For the general case where the bandwidth requirement is larger than one, they present an effective heuristic algorithm. Their simulation results show that the average difference between solutions given by the efficient scheme and optimal ones in terms of call blocking ratio is only 7%. Compared with the shortest path routing, our interference-aware routing algorithms combined with their bandwidth allocation algorithm always reduce call blocking ratio.

The seventh paper by Q. Ni, T. Li, T. Turletti, and Y. Xiao investigates the saturation throughput performance achieved at the MAC layer, in both congested and error-prone channels. The authors provide a simple and accurate analytical model to calculate the MAC throughput with saturated sources. The model is validated through extensive simulation results. Their results show that channel errors have a significant impact on the system performance.

The eighth paper by D. Wu overviews the issues and techniques in QoS provisioning for wireless networks, and present some of our recent results in this area. Specifically, he provides a survey on the results in five sub-areas, namely, network services models, traffic specification, packet scheduling for wireless transmission, call admission control in wireless networks, and wireless channel characterization. For each sub-area, he addresses the particular issues, reviews major approaches and mechanisms, and discusses the trade-offs of the approaches.

The ninth paper by Y. Xu, H. Liu, and Q. Zeng proposes a preemptive priority handoff and adaptive resource allocation scheme. DiffServ PHB groups are mapped into different wireless and mobile QoS classes. Traffic flows are categorized into these classes in order to allow the system to allocate different bandwidth and make resource reservation according to their priorities. Higher priority traffic flows are permitted to preempt lower priority flows in service. Lower ones, on the contrary, can expand their bandwidth into areas reserved for higher priority traffic flows for better resource utilization. They use both analytical model and simulation to evaluate the system performance in terms of blocking probabilities, forced termination probabilities, and delay. The forced termination probability of high priority traffic flows can be decreased significantly by introducing the preemptive priority scheme. Therefore, this scheme can be used in wireless part of the system along with DiffServ to give further guarantee for low delay, low jitter and low loss services to high priority services.

The tenth paper by Y. Zhu and Z. Niu focuses on multirate WLANs and proposes an adaptive transmis-

sion control scheme, which adapts the transmission probability according to the number of active stations, transmission rates, and channel conditions. At first, an analytical model is built in terms of the proposed scheme to explore the throughput of the network. Then, by means of the characteristics of practical system, a heuristic algorithm is developed to approach the maximum throughput on-line. Extensive numerical calculations and simulations based on NS-2 are implemented to evaluate the performance of the proposed algorithm and the impact of inaccurate estimation of parameters. The results show that their algorithm outperforms the existing adaptive algorithms in imperfect channel, and insensitive to inaccurate estimation of parameters.

In closing, we would like to thank the support from the Editor-in-Chief Dr. Mohsen Guizani, and the contributions from authors and reviewers, to make this special issue possible.

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Guest Editors' Biographies

Wei Li is currently an associate professor in the Department of Electrical Engineering and Computer Science at the University of Toledo, U.S.A. He received his Ph.D. from the Chinese Academy of Sciences in 1994. Dr Li's research interests are in the routing protocols and security in wireless internet and mobile ad hoc networks; adaptation, design and implementation of dynamic models for wireless and mobile networks; radio resource allocations, channel schemes and handoff strategies in wireless multimedia networks; bio-molecular networks, information systems, mobile and high-performance computing; queueing networks, reliability networks, decision analysis, and their applications in communications networks etc. Dr. Li has published over 60 peer-reviewed papers in professional journals, over 20 referred papers in the proceedings of professional conferences and three books. Dr. Li is currently serving as an editor for *EURASIP Journal on Wireless Communications and Networking*, for *International Journal of Computer and their Applications*, and for *International Journal of High Performance Computing* and *Networking*. He is also serving or has served as a co-chair/TPC member/session Chairs for some IEEE professional conferences such as IEEE ICC'05,04,02, IEEE GlobCom'05,03, IEEE WCNC'05,04,00, IEEE WirelessCom'05, Qshine'05,04, IEEE VTC'03, etc. Dr. Li is listed in Who's Who in the World (November 2005), Who's Who in America (October 2005), Who's Who among Executives and Professionals (2004/2005 Honors Edition), Who's Who in Science and Engineering (December 2004), and Who's Who in Engineering Academia (2002). He was once a recipient of Hong Kong Wang Kuan Cheng Research Award in 2003 and U.S. Air Force Summer Faculty Fellowship in 2005.

Daehyoung Hong is currently a professor in the Electronic Engineering Department of Sogang University, Korea. He received his Ph.D. in Electrical Engineering from the State University of New York at Stony Brook 1986. He joined Motorola Communication Systems Research Laboratory, Schaumburg, IL, U.S.A., in 1986 where he was a senior staff research engineer and participated in the research and development of digital trunked radio systems (TRS) as well as CDMA digital cellular systems. He joined the faculty member of the Electronic Engineering Department of Sogang University, Seoul, Korea, in 1992, where he is currently a Professor. His research interests include design, performance analysis, control algorithms, and operations of wireless access network and communication systems. He has published numerous technical papers and holds several patents in the areas of wireless communication systems. He has been a consultant for a number of industrial firms. He has been active in a number of professional societies. He now serves as vice director of the Asia/Pacific Board of the IEEE ComSoc, and as chair of 2.3 GHz Portable Internet (WiBro) Project Group (PG302), Telecommunications Technology Association (TTA), Korea.

Demetrios Kazakos is currently a professor and chair of the Electrical and Computer Engineering Department in the University of Idaho, U.S.A. He received his Doctor of Philosophy degree from the University of Southern California in 1973. In 1975, he started his academic career as an assistant professor at the Electrical Engineering Department of the State University of New York at Buffalo. In 1980, he moved to the Electrical Engineering Department of the University of Virginia as associate professor, and was promoted to professor in 1985. In 1992, he was elevated to the grade of fellow of IEEE, for

his research in two areas: Enhanced Algorithms for Multiuser Multiaccess Networks and Statistical Pattern Recognition. In 1993, he accepted the position of head of the Electrical and Computer Engineering of the University of Southwestern Louisiana. At the same time, he has always been a very active participant in IEEE conference organizing and editorial activities. He was editor of the *IEEE Transactions on Communications* for 5 years, Technical Program Chair for two major IEEE Conferences, and member of the Technical Program Committee for numerous IEEE conferences. In 1994, Dr Kazakos became the Director of the new Ph.D. program in Telecommunications at the University of Southwestern Louisiana. In 1983, he started a new company named HITEC, Inc, which undertook several Research and Development projects in Information Technology, funded by the U.S. Department of Defense and the European Community. In 2001, he undertook the position of professor and chair of the Electrical Engineering and Computer Science Department at the University of Toledo. In 2004, he moved to the University of Idaho, as professor and chair of the Electrical and Computer Engineering Department, a position that he holds at present. Overall, he has published about 165 refereed journal papers, book chapters and conference proceeding papers, as well as two books. At present, he is in three Editorial Boards, and continues to participate in many Technical Program Committees for several conferences.

Li-Chun Wang is currently an associate professor in the Department of Communication Engineering of National Chiao Tung University, Republic of China. He received his Ph.D. in Electrical Engineering from the Georgia Institute of Technology, Atlanta in 1996. From 1990 to 1992, he was with the Telecommunications Laboratories of the Ministry of Transportations and Communications in Taiwan (currently the Telecom Labs of Chunghwa Telecom Co.). In 1995, he was affiliated with Bell Northern Research of Northern Telecom, Inc., Richardson, TX. From 1996 to 2000, he was with AT&T Laboratories, where he was a senior technical staff member in the Wireless Communications Research Department. Since August 2000, he has been an associate professor in the Department of Communication Engineering of National Chiao Tung University in Taiwan. His current research interests are in the areas of cellular architectures, radio network resource management, cross-layer optimization, and cooperation wireless communications networks. Dr Wang was a co-recipient of the Jack Neubauer Memorial Award in 1997 recognizing the best systems paper published in the *IEEE Transactions on Vehicular Technology.* He is holding three US patents and one more pending. Currently, he is the Editor of the *IEEE Transactions on Wireless Communications*.