Guest Editorial Cross-layer Optimized Wireless Multimedia Communications

Recent advances in wireless and mobile communications certainly provide ample opportunities for introducing new services that allow for the development of novel and exciting multimedia applications. Supporting multimedia communications over wireless networks with limited and highly varying bandwidth is however quite challenging due to severe constraints such as stringent quality of service (QoS) requirements and limited battery power, as well as heterogeneity in networks, protocols and standards. Cross-layer design methodologies that rely on interaction between the different protocol layers, hold great promises for addressing these challenges and for providing reliable and high-quality end-to-end performance in wireless multimedia communications. The special issue reports on the latest developments in cross-layer optimized wireless multimedia networking, which currently represents one of the most challenging research problems in multimedia communications.

This exciting special issue has received 78 submissions from an open call for papers that covered all topics of cross-layer optimization for wireless multimedia communications. Due to page budget and timing constraints, many good quality works have been turned away, and 19 papers have finally been selected after a careful and highly competitive review process. These papers are organized into four sections in this special issue, namely quality of service support for wireless networks, system architecture for multimedia over wireless networks, resource allocation in wireless multimedia communications, and multimedia coding and scheduling issues in wireless networks.

The first five papers of the special issue deal with quality of service issues in different multimedia wireless networks. The paper "Cross-Layer Resource Allocation Over Wireless Relay Networks for Quality of Service Provisioning" by Tang and Zhang proposes a resource allocation scheme by integrating information theory with the concept of effective capacity, which connects the physical layer to the data link layer in the relay network contexts. The proposed scheme efficiently supports the diverse QoS requirements for wireless multimedia communications over the amplify-and-forward and decode-and-forward mobile relay networks. The paper "Cross-layer QoS Analysis of Opportunistic OFDM-TDMA and OFDMA Networks," by Chang, Chien and Kuo, analyzes the performance of multiuser orthogonal frequency division multiplexing (OFDM-TDMA) and orthogonal frequency division multiple access (OFDMA) networks in support of multimedia transmission. It measures QoS parameters at different layers to demonstrate the superiority of OFDMA versus OFDM-TDMA in supporting multimedia services. Next, the paper "Cross-Layer Optimized Conditions for QoS Support in Multi-Hop Wireless Networks With MIMO Links," by Hamdaoui and Ramanathan, develops methods that exploit the benefits of multiple antennas to enable multi-hop wireless networks with flow-level QoS capabilities. It proposes a cross-layer statistical approach for each node to determine the amount of spatial reuse and/or multiplexing offered by multiple antennas and highlights the importance of considering cross-layer couplings into the development of flow acceptance methods. The following paper, "A Cross-Layer Approach for WLAN Voice Capacity Region," by Cheng, Ling, Song, Cai, Zhuang, and Shen, proposes a framework that combines the network level queue analysis and MAC-level non-saturated distributed coordination function modeling. It allows to determine the maximum number of on/off voice flows that can be supported over a wireless local area network, under a quality of service constraint. Finally, in the paper, "100+ VoIP Calls on 802.11b: The Power of Combining Voice Frame Aggregation and Uplink-Downlink Bandwidth Control in Wireless LANs," Yun, Kim, Lee and Kang implement adaptive frame aggregation and uplink/downlink bandwidth equalization. It results in reduced congestion and better bandwidth allocation, which eventually allows to significantly increase the number of simultaneous VoIP calls, while still providing a reasonable call quality.

The second set of four papers describe architecture and design aspects of wireless multimedia systems. The first paper, "Cross-Layer Architecture for Adaptive Video Multicast Streaming over Multi-Rate Wireless LANs," by Villalón, Cuenca, Orozco-Barbosa, Seok and Turletti, considers jointly three layers of the protocol stack (the application, data link, and physical layers) in order to optimize system performance. A rate adaptation mechanism, together with cross-layer signaling, is shown to greatly improve the performance of multicast video streaming in WLAN scenarios. The paper "System Architecture and Cross-layer Optimization of Video Broadcast over WiMAX," by Wang, Venkatachalam and Fang, identifies key design issues such as synchronization, energy efficiency and robust video quality. An end-to-end solution is proposed to address these issues, and improve the coverage and spectrum efficiency while satisfying video quality requirements in WiMAX infrastructures. In the work "DYNAMO: A Cross-Layer Framework for End-to-End QoS and Energy Optimization in Mobile Handheld Devices," Mohapatra, Dutt, Nicolau and Venkatasubramanian present a framework for evaluating power and performance tradeoffs for distributed mobile multimedia applications. Adaptations at all levels of the system hierarchy - applications, middleware, OS, network and hardware - can be effectively coordinated with distributed middleware layer, for optimized performance and dramatic

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energy savings. Finally, the paper "Multi-hop Wireless Backhaul Networks - A Cross-Layer Design Paradigm," by Cao, Wang, Kim and Madihian, proposes a cross-layer framework for joint optimal routing, link scheduling, beamforming and power control for admission control in multi-hop wireless backhaul networks. A method is proposed to decouple routing and scheduling problems, which are eventually coordinated by a pricing mechanism in order to achieve the optimal overall system objective. The authors finally discuss system performances, and implementation issues in the context of IEEE 802.16.

The next set of four papers deal with the allocation of resources among simultaneous wireless multimedia streaming sessions. The paper "Content-Aware Resource Allocation and Packet Scheduling for Video Transmission Over Wireless Networks," by Pahalawatta, Berry, Pappas and Katsaggelos, proposes a dynamic scheduling scheme for multi-user scenarios. The proposed strategy, based on channel quality and gradients of video distortion functions, allows for an efficient allocation of resources within a session, and across multiple users. The paper "Cross-Layer Optimized Rate Adaptation and Scheduling for Multiple-User Wireless Video Streaming," by "Özçelebi, Sunay, Tekalp and Civanlar, presents a strategy that achieves maximum quality of service for each user, and QoS fairness among users. It solves a multi-objective optimization framework that allows to outperform state-of-the-art wireless schedulers in IS-856 (1xEV-DO) environments. In "Multi-user Video Streaming over Multi-hop Wireless Networks: A Distributed, Cross-layer Approach Based on Priority Queuing," Shiang and van der Schaar propose a low-complexity, distributed, and dynamic routing algorithm based on priority queuing that optimizes transmission strategies across layers. It allows to maximize the decoded video quality of multiple users engaged in simultaneous real-time streaming sessions and achieves better performances than static flow-based solutions. Finally, the paper "Upstream Congestion Control in Wireless Sensor Networks through Cross-Layer Optimization," by Wang, Li, Sohraby, Daneshmand and Hu, proposes a priority-based congestion control protocol (PCCP) for convergent upstream traffic generated by wireless multimedia sensor nodes. PCCP resides between the MAC and network layers, and achieves proportional fair bandwidth allocation with fast and efficient congestion control and very low buffer requirements.

The final set of six papers addresses several issues in multimedia scheduling and coding for wireless networks. The paper "Payload Length and Rate Adaptation for Multimedia Communications in Wireless LANs," by Choudhury and Gibson, presents a theoretical framework to optimize single user throughput by selecting the transmitted bit rate and payload size as a function of channel conditions. Careful payload length adaptation significantly improves the throughput performance at low signal to noise ratios (SNRs), while rate adaptation with higher payload lengths provides better throughput performance at higher SNRs. Next, "Towards Universal Power Efficient Scheduling In Gaussian Channels," by Rajan, addresses the problem of scheduling packets for transmission during a sequence of time slots for both deterministic and statistical delay guarantees. A constrained minimization problem leads to substantial power savings for small increases in delay. The paper "Packet Prioritization in Multihop Latency Aware Scheduling for Delay Constrained Communication," by Liang and Dong, focuses on optimizing the packet transmission strategy in delay-constrained multihop wireless networks. An analytical framework based on recursive non-homogeneous Markovian analysis is developed to study the effect of transmission priorities on the packet loss probability, in order to achieve a proper balance between distance and lifetime in selecting a transmission policy. In "Cross-Layer Optimized Multipath Routing for Video Communications in Wireless Networks," Kompella, Mao, Hou and Sherali propose an efficient algorithm that computes optimal routes for transporting multiple description video streams. The solution based on a branch-and-bound framework embedded with a novel relaxation method is shown to quickly compute a set of routes with an objective value close to optimum. The next paper entitled "Cross-Layer Optimization for Video Summary Transmission over Wireless Networks," by Wu, Ci, and Wang proposes to optimize jointly the source coding, retransmissions, adaptive modulation and channel coding. It implements Lagrangian relaxation and dynamic programming to provide in efficient video quality and content distribution under delay constraints. Finally, in the paper "Distributed Joint Source-channel Coding of Video Using Raptor Codes," Xu, Stanković and Xiong propose a cross-layer coding solution for scalable video transmission over wireless networks. The joint design of distributed source coding and near-capacity channel coding is shown to offer improved performance in erasure resilient video transmission.

The guest editorial team would like to thank all authors for submitting their quality work to this special issue, and to the numerous reviewers whose hard work and expert contributions are certainly the cornerstone in the quality of this successful special issue. Finally, special thanks go to Prof. Nick Maxemchuk and Prof. Pamela Cosman, Editors-in-Chief for approving and making this issue possible, and to Prof. Gunnar Karlsson for his priceless guidance along the whole process of this special issue. Many thanks to Marlene Sealey-Frey, Sue Lange and Sue McDonald for taking care of all the details in the development of this journal. We wish you a very pleasant read of the high quality papers presented in this issue.

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