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Editorial

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Next-generation wireless communications aim to provide seamless service to mobile users, anywhere, anytime. One important aspect of wireless communications is the dynamic behavior. The structure of conventional protocols is inflexible, requiring layers to communicate in a strict manner. Specifically, layers are designed to operate under worst-case conditions, rather than adapting to conditions as they change. This leads to inefficient use of both spectrum and energy.

Adaptation allows network protocols and applications to observe and respond to channel variations. Central to adaptation is the concept of cross-layer design. In general, cross-layer design involves five key layers in the protocol stack (i.e., application layer, transport layer, network layer, medium access layer, and physical layer). According to the varying network and channel conditions, applications can adjust their behavior, such as error resilience, via forward error correction and data transmission rates. Adaptation can also take place in underlying layers such as TCP and UDP, so a single application can transparently operate on top of different networks. Application characteristics such as QoS requirements and packet priority can be used to coordinate lower layers for improved resource efficiency. Finally, also important to adaptation is each layer's ability to first estimate current and future network and channel conditions, and then exchange information across different layers. This is an emerging area where recent work has resulted in significant advances. With increased attention and focus from researchers in communications, signal processing, and other networking areas, it holds the promise of even greater results in the future.

Observing the need for an in-depth treatment of this topic for both academia and industry readers, we have put together this special issue. All of the submitted papers went through peer reviews to ensure their correctness, technical significance, and relevance to the special issue. Although all submissions were of high quality, we had room for only eleven papers that best fit the theme, and many fine papers could not be included in this issue. We hope that these papers will find their intended audience through other journals, magazines, or conference proceedings.

This special issue consists of eleven papers categorized into three distinct but related topics: MAC centric cross-layer design in mobile ad hoc networks, QoS-driven resource allocation, and multimedia delivery over wireless networks via cross-layer design.

MAC centric cross-layer design in mobile ad hoc networks

Mobile ad hoc networks and mobile terminals share radio resources without centralized coordination. The choice of mechanisms to access radio channels is extremely important for both resource efficiency and QoS support. In particular, interactions between layers (network, MAC, and physical) provide valuable information in the design of MAC techniques.

The paper by Realp and Pèrez-Neira addresses this problem by presenting a novel decentralized multipacket MAC protocol that employs a collision resolution mechanism based on traffic load while exploiting the multipacket reception capability at the physical layer. The MAC protocol assigns each time slot to a node, but allows other nodes to share CDMA codes left over unused by the primary node. Analytical and experimental results demonstrate the effectiveness of this approach.

Butala and Tong address the problem of on-demand dynamic channel selection in CDMA-based ad hoc networks by jointly considering MAC layer scheduling and physical layer request detector. Such a design provides contention-free transmissions and helps to eliminate the dependency of the number of channels (spreading gain in this work) on network size. Analysis and simulations reveal that the threshold of request detector is crucial for system performance.

Power control and scheduling are two fundamental issues in ad hoc networks, although they are handled separately by the physical and MAC layers. The next paper by Wang et al. addresses the problem of joint power control and scheduling in ad hoc networks to support multicast traffic. The authors first propose an algorithm that provides the optimal power control solution where it exists, that is, provides the set of powers to be used in order to guarantee good quality at all receivers. If such a solution does not exist, a decentralized scheduling is introduced to eliminate strong interferers and provide a feasible power control solution for the remaining nodes. Simulation results confirm that the proposed approach provides high success rates for multicast traffic.

QoS-driven resource allocation

In cross-layer design, application characteristics such as QoS requirements and packet priority can be used to coordinate lower layers, MAC and physical layers in particular, for improved resource efficiency. The next paper by Poulliat et al. investigates link adaptation strategies based on the maximization of the minimum information rate under certain SINR constraints. The authors develop an optimal solution when transmissions can take continuous rates, and derive analytical bounds on average performance. They also provide solutions for more realistic scenarios considering saturation and quantization of the rate's space. Extensive simulations confirm the validity of analytical results, and reveal that rate saturation and quantization result in performance loss.

Pricing-based service priority and traffic classification can serve as QoS indicators for link layer resource allocation. Chen et al. investigate the MAC layer scheduling and power adaptation in frequency-hopping OFDM systems that are QoS aware. The authors introduce a set of QoS-aware MAC states that allow a scheduler to select the appropriate transmission formats and packet priorities based on physical channel conditions and QoS requirements. Extensive experimental results show that the proposed cross-layer design enables balanced QoS support for diverse user requests.

Wong et al. discuss QoS support among all protocol layers and show that they are intertwined. The authors develop an analytical model to characterize the performance of multiclass services at the connection, packet, and link levels. System utilization can be maximized by coupling the optimizations at different levels. The authors also conduct extensive simulations which confirm the utilization gains from the cross-layer design.

MAC protocols play an essential role in integrating different services, by satisfying the requirements of each service while maintaining high resource utilization. However, there is a fundamental tradeoff between network utilization and user (QoS) satisfaction. The next paper by Kwasinski et al. addresses this problem in the context of integrated voice and data networks. The authors propose a low-complexity intelligent MAC protocol that sets the voice/data boundary based on the number of active voice calls in the system (a metric of network utilization) and a maximum average normalized distortion threshold (a metric of user satisfaction). Mathematical analysis and experimental results confirm that the proposed protocol provides performance comparable with the state-of-the art algorithms with significantly lower complexity.

Multimedia delivery over wireless networks via cross-layer design

Multimedia delivery over wireless networks is inherently challenging due to a combination of strict and yet distinct QoS requirements for each media type and constantly changing channel conditions. Zhang et al. discuss a cross-layer design framework to provide QoS support to deliver multimedia over the wireless Internet. The authors introduce a cross-layer architecture combining application-, transport- and link-level adaptations, and proceed to explore recent advances in each individual component.

Real-time video streaming over wireless networks is one of the most attractive and yet challenging propositions in multimedia delivery. The different nature of the wireless channel compared to the wireline environment calls for radically different approaches for wireless video streaming. The next paper by Shan deals with cross-layer techniques for adaptive video streaming over wireless networks. The paper presents a set of end-to-end application layer techniques that adapt to both channel and data, in particular, packetization, FEC coding, and priority-based retransmission, that take into account the characteristics of radio link protocol (RLP) layer. Experimental results in terms of both media quality and packet delay confirm the advantage of the proposed mechanisms.

Overcomplete frame expansions have been introduced as a signal representation resilient to wireless channel erasures. Rath and Guillemot introduce a characterization of discrete frames that provides analysis for the reconstruction of errors and the usefulness of each frame. The authors also propose a subspace algorithm for localizing errors in the frame expansion coefficients. The proposed approach allows for error correction in addition to erasure recovery. Simulation results show that the proposed algorithm improves error localization accuracy for image transmission.

Given that certain multimedia data types are error-resilient, it is possible to pass corrupt data from the link layer up to the network and application layers to improve bandwidth efficiency. Welzl provides an overview of developments and issues related to the passing of corrupt data across network layers. He draws special attention to investigating the impact of link layer error recovery, IPv6 support, and security concerns. The author conclusion is that effective and well-designed interlayer communication is essential to cross-layer design, warranting further in-depth investigations.

Finally, we would like to thank all of the authors who responded to our call for papers for their valuable contributions. We would also like to express our sincere thanks to all the reviewers who dedicated their precious time to provide detailed and helpful reviews. Last but not least, we would also like to acknowledge the enlightening support of Professors Marc Moonen, and K. J. R. Liu from EURASIP JASP's Editorial Board, and also Professor Bastiaan Kleijn, a former member of the Editorial Board. With the help of these many contributors, we have fulfilled our expectations, and hope that this special issue offers a considerable and timely contribution to the area of cross-layer design for communications and signal processing.

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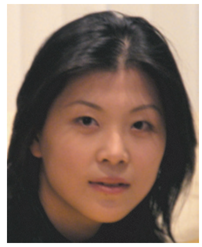

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