UNDERWATER WIRELESS COMMUNICATIONS AND NETWORKS: THEORY AND APPLICATION: PART 2

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The Earth is a water planet, two-thirds of which is covered by water. With the rapid developments in technology, underwater wireless communications and networks have become a fast growing field, with broad applications in commercial and military water-based systems. The need for underwater wireless communications exists in applications such as remote control in the off-shore oil industry, pollution monitoring in environmental systems, collection of scientific data from ocean-bottom stations, disaster detection and early warning, national security and defense (intrusion detection and underwater surveillance), as well as new resource discovery. Thus, the research into new underwater wireless communication techniques has played the most important role in the exploration of oceans and other aquatic environments. In contrast to terrestrial wireless radio communications, the underwater channel poses serious technical challenges depending on the communications modalities (e.g., acoustic, optical, or RF/magnetic) employed. These include, but are not limited to, ambient channel noise, severe attenuation, propagation delay, multipath, frequency dispersion, bio-fouling, lack of access to precise time synchronization (GPS), and constrained bandwidth and power resources. These challenges also provide an opportunity for design of hybrid and adaptive transmission, such as the underwater acoustic and optical communications and networks, which have somewhat complementary properties, with potential for longer range and higher bandwidth networked communications in size- and power-constrained modems and mobile unmanned systems.

Inspired by the attractive and unique features and potential benefits of advanced underwater communications, the topic of underwater wireless networks has attracted increasing attention from researchers not only in academia, but also in the military and industrial sectors. While a great deal of research efforts have been made in recent years on underwater wireless networks, the aforementioned challenges posed by underwater acoustic as well as optical wireless channel exploitation in future underwater wireless system developments still remain an open problem. As we present Part 2 of this Feature Topic of *IEEE Communications Magazine* focusing on underwater wireless communications and networking, we aim to address the urgent needs in both theory and application aspects of industry, military, and the research community in order to better understand the recent progress, explore the future potential research directions, and define new research paradigms in underwater wireless communications and networks. The response to our Call for Papers on this Feature Topic was overwhelming, with a total of 52 articles submitted from all around the world. Going through the rigorous two-round review process, Part 1 of this Feature Topic, which consisted of eight excellent articles addressing various aspects of underwater wireless networks, was published in the November 2015 issue of *IEEE Communications Magazine*. Part 2 of this Feature Topic presents the following four excellent articles focusing on the key issues and emerging concepts of contemporaneous underwater wireless networks and techniques.

The first article, "RSS-Based Secret Key Generation in Underwater Acoustic Networks: Advantages, Challenges, and Performance Improvements," overviews the advantages, explores the major challenges, and evaluates the performance improvements of received signal strength (RSS)-based key generation techniques in underwater acoustic wireless networks. The second article, "Design Guidelines for Opportunistic Routing in Underwater Networks," investigates the two main building blocks for the design of opportunistic routing protocols for underwater sensor networks — candidate set selection and candidate coordination procedures — and discusses how the resulting approaches are related to the opportunistic routing protocol designs for different scenarios in underwater sensor networks. The third article, "A Journey toward Modeling and Resolving Doppler in Underwater Acoustic Communications," surveys the evolution of Doppler modeling and resolution in underwater acoustic communications through five modeling stages: quasi-static model, uniform Doppler shift model, basis expansion model (BEM), plus path speed model and non-uniform path speed model, and characterizes their respective performance matrixes. The fourth article, "Impulse Response Modeling for General Underwater Wireless Optical MIMO Links," investigates underwater wireless optical communications (UWOC) multiple-input multiple-output (MIMO) systems with M light-sources and N detectors, focusing on the impulse response to characterize the temporal behavior of UWOC links and proposing an M-order weight Gamma function polynomial (WGFP) to model the impulse response of $M \times N$ UWOC MIMO links.

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Biographies

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JUN-HONG Cui received her Ph.D. degree from the University of California Los Angeles (UCLA) in 2003. She is now a full professor at the University of Connecticut. Her recent research mainly focuses on underwater sensor networks, autonomous underwater vehicle networks, cyber-aquatic systems, smart ocean technology, and ocean computing. She co-founded the ACM International Conference on Underwater Networks and Systems, and is now serving as its Steering Committee Chair. She has received an NSF CAREER Award and an ONR Young Investigator Award.

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