Wireless Underwater Communications

Milica Stojanovic
Massachusetts Institute of Technology
millitsa@mit.edu

Wireless information transmission through the ocean is one of the enabling technologies for the development of future ocean-observation systems, whose applications include gathering of scientific data, pollution control, climate recording, early prediction of natural disturbances, detection of objects on the ocean floor, and transmission of images from remote sites. Implicitly, wireless signal transmission is crucial for control of autonomous underwater vehicles which will serve as mobile nodes in the future information networks of distributed underwater sensors. The ability to communicate wirelessly provides advantages of collecting data without the need to retrieve the instruments, and maneuvering underwater vehicles and robots without the burden of cables.

Underwater wireless communications are usually established using acoustic waves, while electro-magnetic waves remain confined to short distances. Acoustic communications are governed by three factors: limited bandwidth, time-varying multipath propagation, and low speed of sound underwater. Together, these constraints result in a communication channel of poor quality and high latency, thus combining the worst aspects of terrestrial mobile and satellite radio channels into a communication medium of extreme difficulty, which poses challenging research problems. To achieve high information throughput on such channels, phase and amplitude modulation/detection techniques must be considered because of their bandwidth efficiency. Signal processing methods for bandwidth-efficient underwater communications are based on adaptive channel tracking, equalization, and multichannel combining. These methods have been a topic of extensive research over the past decade, resulting in the development of first high-speed underwater acoustic modems. Today, research is active on the design of communication algorithms and protocols that will enable integration of point-to-point links into autonomous underwater networks.

In this presentation, we overview the channel characteristics, and outline the signal processing methods for state-of-the-art underwater communication systems. We also address methods for multiple-access underwater communications, which enable channel sharing among the users, thus forming the basis of future underwater wireless communication networks. The performance of various techniques is discussed through a series of experimental results, which include transmission over distances ranging from a few kilometers in shallow water to

hundreds of kilometers in deep water, at highest bit-rates demonstrated to date. We conclude with an outline of open research problems.

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Milica Stojanovic *graduated from the University of Belgrade, Serbia, in 1988, and received the M.S. and Ph.D. degrees in electrical engineering from Northeastern University, Boston, MA, in 1991 and 1993. She is currently a Principal Scientist at the Massachusetts Institute of Technology, and also a Guest Investigator at the Woods Hole Oceanographic Institution. Her research interests include digital communications and statistical signal processing, and their applications to mobile radio and underwater acoustic communication systems.*