Surface Gateway Placement in Underwater Acoustic Networks

Dr. Reda Ammar, Prof. and Chair,
Computer Science and Engineering Department, University of Connecticut

Underwater Wireless Sensor Networks is revolutionizing sensing technology in underwater environments. The applications of UWSN technology span a wide spectrum of scientific, commercial and defense applications, such as scientific exploration, environmental monitoring, and tactical surveillance. Due to physical channel limitations, the typical mode of underwater wireless communication is acoustic signals, which are both slow and limited in bandwidth.

The deployment of multiple surface-level radio-capable gateway nodes forms an interesting network architecture that integrates underwater acoustic communication and aerial radio communication. This heterogeneous architecture can substantially improve the performance of underwater sensor network (UWSN) deployments, provided that gateway nodes are placed in the suitable locations. In this research, we studied the problem of gateway placement in underwater sensor networks in order to maximize the cost-benefit of such architecture. We developed a mixed integer programming (MIP) Gateway Deployment Optimization (GDO) framework to improve the performance of UWSN through optimal gateway placement. We investigated the performance advantages of the surface-gateway architecture in the optimal case. We developed various heuristic algorithms for efficiently finding a near-optimal solution to this NP-hard deployment optimization problem, and compared their complexity and quality.
We demonstrated that using a mesh of candidate gateway deployment locations limits the quality of the deployment optimization solution, and developed a novel technique for enhancing the problem formulation, by deriving candidate gateway locations from the geometry of the underwater deployment. We extended the GDO framework to solve the gateway deployment problem for maximizing network lifetime and presented a method for balancing this goal with other performance optimization objectives, such as the minimization of average end-to-end delay.