UNIVERSITY of HOUSTON

CULLEN COLLEGE OF ENGINEERING

Underwater Sonar Placement for Maritime Surveillance

Taofeek Biobaku [2], Gino Lim [2], Selim Bora[1], Jaeyoung Cho [2], and Hamid Parsaei [1]

[1] Texas A & M University at Qatar; [2] Department of Industrial Engineering, University of Houston.

TEXAS A&M UNIVERSITY at QATAR

Background

- It is widely accepted that over 90% of world international trade travels by sea
- Global economic inter-dependency among cities and nations is largely dependent on the success of the maritime industry
- With the incidence of terrorism, piracy and arson attacks, it becomes necessary to protect ports, waterways and other maritime infrastructures from these attacks

Objectives

- Ensure detection of potential water-borne threats by placing under-water sonars within a port or waterway of interest.
- Propose optimization formulations to fulfill model requirements:

  Sonar Placement: Actual location of a deployed sonar.

  Sonar Coverage: Ability of a deployed to provide 'cover' for its placement location and other locations in its neighborhood based on the sonar type.

- Optimization Goals
  Goal #1: Detection probabilities of regions
  Goal #2: Number of regions protected

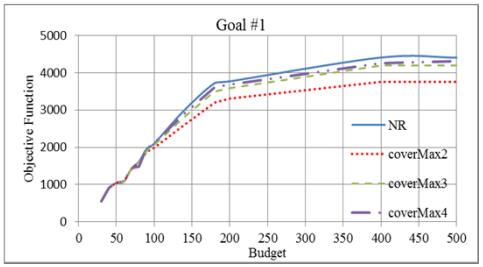
Methods

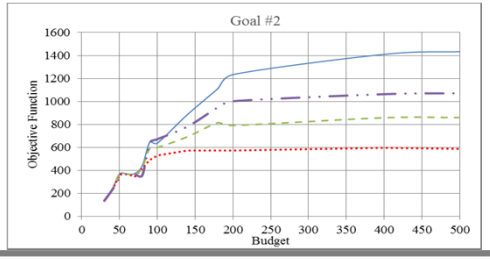
- Develop risk-based, multi-objective mathematical model-include physics and principles behind sonar technology and underwater acoustics
- Include sonar mobility in deployment
- Implement and verify model using numerical experiments
- Use proposed hexagonal grid system introduced and validated in our earlier work
- Multi-periodic surveillance: Changing criticality per period

Numerical Experiments

Solution Approach : Lexicographic Multi-Objective Method with goal #1 having the priority.

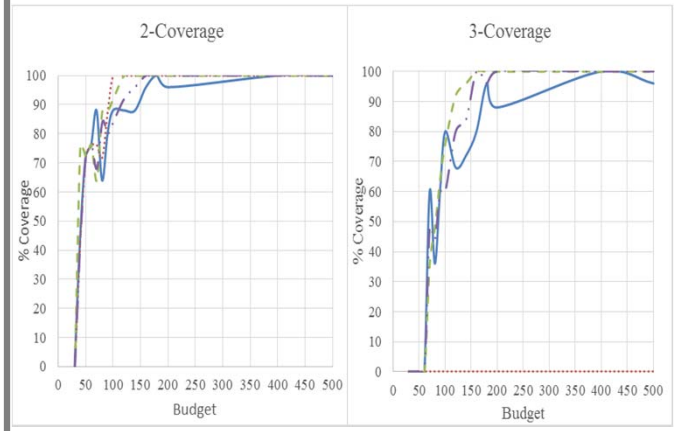
Static and mobile sonars considered (with different costs, ranges, and coverage orientations: Omni-directional,180° Coverage & 90° Coverage)





Numerical Experiments: Sensitivity Analysis

n-Coverage



Results-Discussions

- Multi-periodic deployment scheme not only generally improves the objective functions but also permits other regions initially un-covered to be eligible for coverage at other time periods
- Sonar mobility (patrol-scheme) helps to increase total detection probabilities.
- Sonar mobility over multi-period helps to reduce coverage "holes".
- Sensitivity Analysis suggests the desirability of restricting maximum cover per grid to a small integer.
- Current work-extensions: Development of Heuristics(for large-scale problems).

Acknowledgements

This work was made possible by the NPRP award [NPRP 4-1249-2-492] from the Qatar National Research Fund (a member of The Qatar Foundation).