CDMA-BASED MULTI-DOMAIN COMMUNICATIONS NETWORK FOR MARINE ROBOTS

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Objectives

Design a CDMA-based communications protocol that can span above, surface and underwater with following capabilities:

- Robustness to frequency selective fading
- Compensates for multi-path effects at the receiver
- Allows receivers to distinguish among signals simultaneously transmitted by multiple devices

Introduction

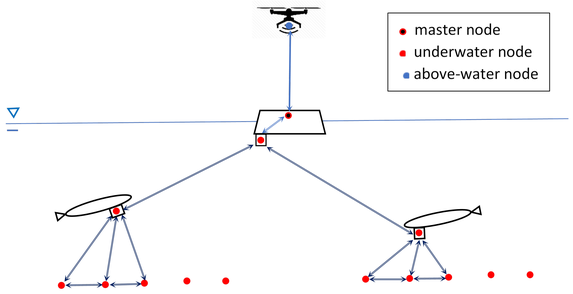

Figure 1:Heterogeneous marine sensor network architecture

UW-ASNs [1] can consist of sensors on UUV and USV which collaborate with above-water robots like UAV to perform, for example, **collaborative monitoring tasks** (Figure 1).

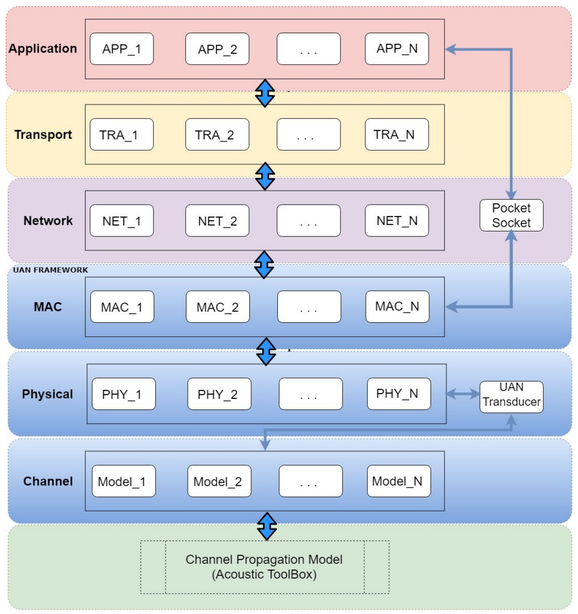

Figure 2:Proposed framework for simulation

Background

The motivation of this research follows the concept of [1][2] where 7-UUVs, 2-USVs, and 1-UAV collaboratively communicate underwater information using **TDMA** for under, on and above water. Proposed, is to use **CDMA** instead so the full channel bandwidth is simultaneously used for multiple signals.
The following tools are being collaboratively used for simulation:

- **MATLAB, Network Simulator-3 [3], Bellhop Acoustic Toolbox [4]**

Important Result

- Determined feasible ranges between UUV and USV as **less than 1 km** for 25 KHz for given conditions.

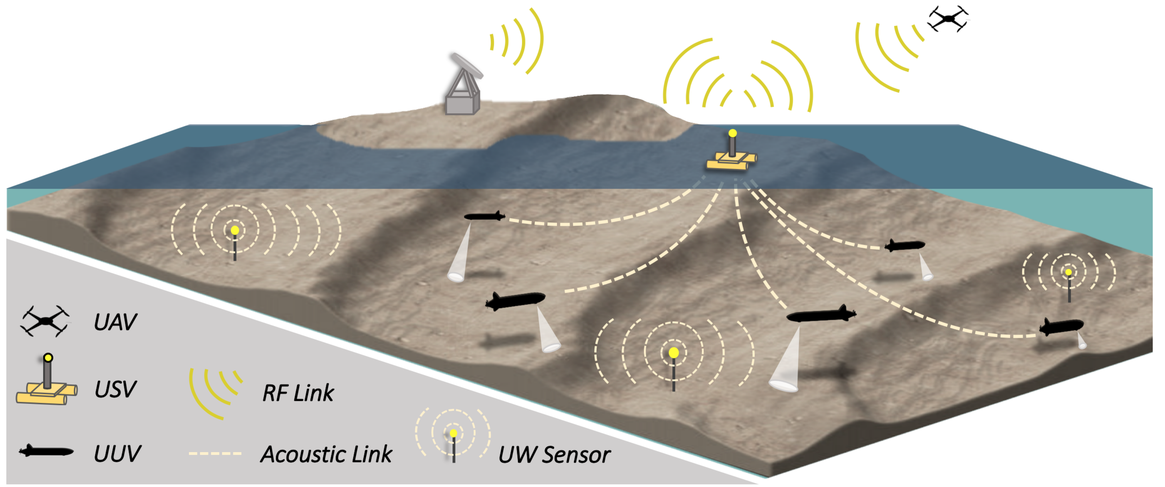

Figure 3:Robotic multi-vehicle collaboration - above and below water

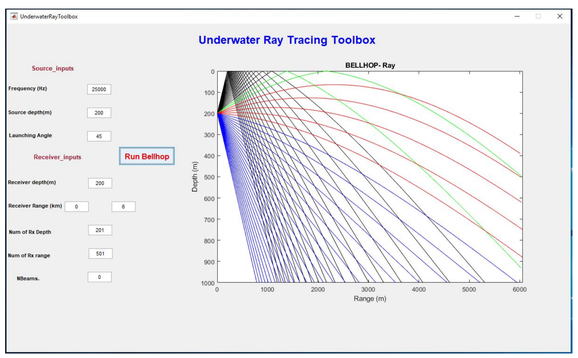

Figure 4:UW Ray Toolbox - MATLAB custom GUI

Methods

The following approach is used to simulate the proposed protocol.

- NS-3 core module & modified CDMA module was used to design UW-CDMA network, uses Bellhop and proposed UW Ray Tracing Toolbox (MATLAB GUI-figure 4)
- Integrated with NS-3's Thorp Propagation Model [3]
- Conventional in-air CDMA for communication between the master node and UAV

Results

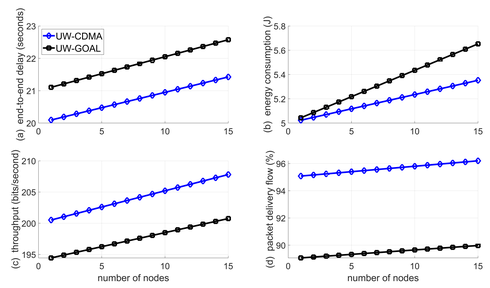

Figure 5:Measures of performance for the UW-CDMA v/s number of nodes relative to UW-GOAL (a) end-to-end delay is 1 second less; (b) energy consumption is 0.2 J less at 15 nodes; (c) the throughput is 5 bits/second higher, and (d) the packet delivery flow is 6 % greater overall.

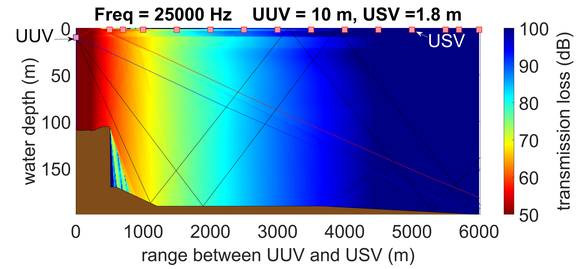

Figure 6:The transmission loss for acoustic signals at 25 kHz in 200 m water depth, The threshold transmission loss was selected as 60 dB.

UAN channel (Figure 6) is a harsh medium due to its spatial-temporal variability. Before any deployment, channel performance analysis, with a function of local ocean environment parameters, gives clear picture of communications system behaviour.

Conclusion & Future Work

The simulation results are encouraging for the proposed CDMA protocol. Its implementation is underway however, merging under, on, and above water models is expected to increase the complexity.

References

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