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Road Map

- Introduction
- Aqua-Lab Overview
- Experiments & Results
- Conclusions & Future Work
The Problem

- Limitation of Field Tests:
  - High costs
  - Time consuming

- Limitation of Simulations:
  - Accurate model: challenging
  - Real environment parameters

- Our solution
  - Develop a “powerful” lab testbed—Aqua-Lab
Advantages of Aqua-Lab

- Provide field test experience in a lab controlled environment
- Facilitate real system development
- Offer flexibility and affordability
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- *Aqua-Lab Overview*
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Aqua-Lab Overview

- Major Components:
  - Acoustic channel: water tank
  - Hardware: acoustic modem, transducer & sound mixer
  - Software: two-level library and emulator
Aqua-Lab: Hardware

- Hardware Setup
  a. Acoustic modem: Micro-Modem
  b. Sound mixer
  c. Water tank
  d. Hydrophone
  e. Underwater speaker
Aqua-Lab: Library

- Low-Level Library
  - Talk to Micro-Modem directly
  - Need to understand modem work flow
  - Could be transparent to users

- High-Level Library
  - Build on top of low-level library
  - Provide socket-like programming model
  - Provide simple tools to test connectivity of modems
Aqua-Lab: Emulator

- Provide an abstract layer
- Could emulate:
  - Complex topology
    - E.g., using 2 modems for bigger topologies
  - Propagation delay
    - At the source, add a delay: distance/speed
  - Attenuation
    - Adjust SNR at receiver
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Experiment Setup

- **Time:** Mar 5\(^{th}\) ~ April 15\(^{th}\), 2007
- **Location:**
  - Field test: Buzzards Bay, MA
  - Lab test: Aqua-Lab, UConn
- **Topology:**
Experiment Setup (Cont.)

- Deployment
One-Hop Delay
Field test: sound speed 1500 m/s
One-Hop Throughput
Vector-Based Forwarding (VBF)

- Location-based routing protocol
- Only nodes in routing pipe forward messages
End-to-end Delay under VBF

Field test

Lab test

Testbed VBF delay

Delay (Sec)

Packet Sequence

Delay (Sec)

Packet Sequence
Environmental Noises

- Readings from Micro-Modem (in dBV):

![Comparison of Noise Levels](image-url)
Emulating Attenuation

- Change/measure SNR at receiver side
- Can estimate SNR in the field test

Estimated SNR in the field test

SNR and Loss Ratio

Average number of retransmissions in field test
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Conclusions

- Aqua-Lab could
  - Emulate complex topology, delay, attenuation
  - Provide an integrated hardware & software platform
  - Obtain experimental results similar to field tests
  - Be accessed remotely through the Internet (see demo)

- The contributions of Aqua-Lab
  - Provide field test experience in lab controlled condition
  - Facilitate real system developing and testing
  - Offer flexibility and affordability
Future Work

- Implement and test other protocols
  - MAC, advanced coding, other routing, etc.
- Explore other acoustic modems
  - S-Modem, R-Modem, Mooring-Modem
- Integrate communication, sensing, and processing
  - Aqua-Mote: in progress ...
THANKS!

- [http://mirro.engr.uconn.edu/UWSN/TestBed.php](http://mirro.engr.uconn.edu/UWSN/TestBed.php)