Aqua-Sim: An NS-2 Based Simulator for Underwater Sensor Networks

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Outline

- Motivations
- System Overview
- Aqua-Sim Components
- Experimental Results
- Conclusions

Motivations

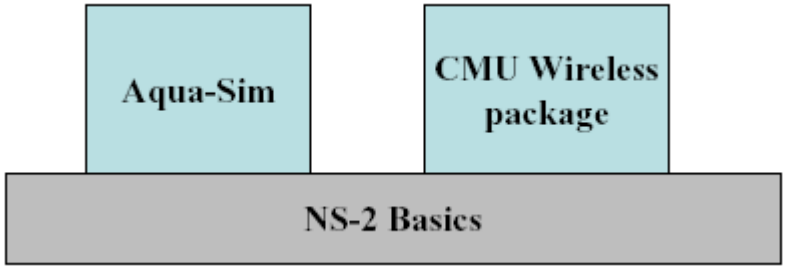
- Increasing interests in underwater networks
- High costs in doing large scale field tests
- Hard to evaluate the performance
- Lack of simulation tools
  - Channel model
  - Long propagation delay
  - Three dimensional topology

Development Platform

- NS-2 simulator
  - A discrete event simulator
  - Widely used
  - Open source
  - Build in C++
- Limitations
  - 2D topology
  - Designed for wired networks
  - Does not support underwater networks

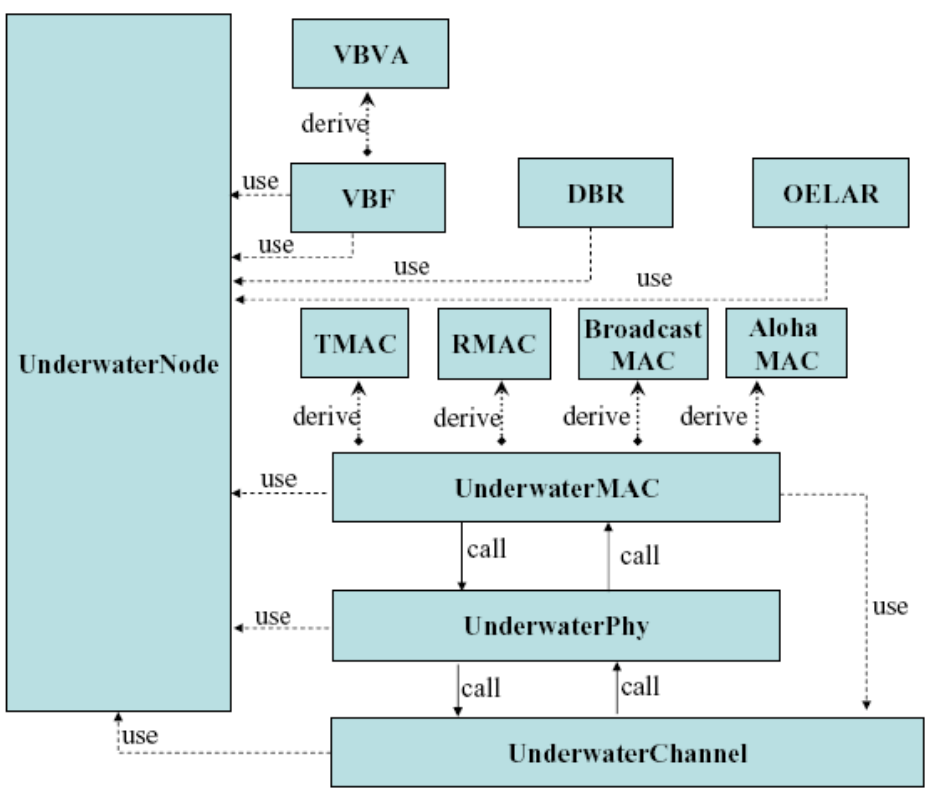
Aqua-Sim Overview

- CMU wireless extension
  - Support wireless mobile networks
  - Not applicable to underwater networks
  - Still for 2D network
- Aqua-Sim underwater extension
  - In parallel with CMU wireless extension
  - Designed for underwater networks
  - Support 3D topology
- Implementation
  - Object-oriented
  - Dual interfaces
    - C++ : Developers
    - Otcl : Users



Class Structure

- Basic classes
  - Entities
    - *underwaterNode*
    - *RMAC, etc.*
  - Interfaces
    - *underwaterMAC*
  - Functions
    - *hash-table, etc.*



Physical Layer Model

- Channel
  - Network entity Class:
    - *UnderwaterChannel*
  - Attenuation model
    - Distance
    - Frequency
  - Transmission range
    - Power
    - Range
  - Propagation
    - Class *UnderwaterPropagation*
    - Introducing delays
- Collision
  - Packets copied to *IncomingChannel*
    - *Maintained by each node*
  - Collision decided by *UnderwaterPhy*
    - Receiving time
    - Receiving power level
- Can be extended to use any complex model

Media Access Control (MAC)

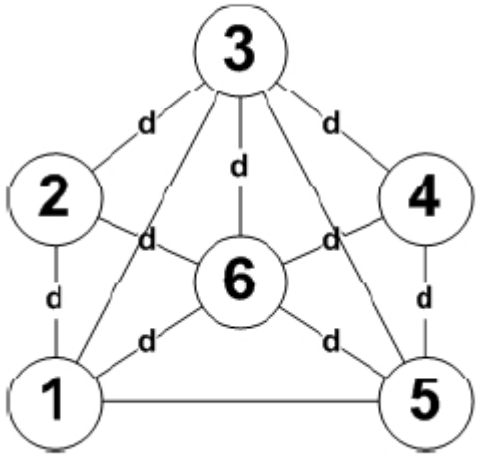
- Abstract interface class:
  - *UnderwaterMac*
- Available protocols:
  - Broadcast MAC
  - Aloha
  - T_u-MAC
  - R-MAC

Network Layer

- Implementation
  - Following NS-2 standard
- Customization
  - Providing various interfaces
- Configuration
  - Using Tcl script
- Available protocols:
  - Vector-Based Forwarding (VBF)
  - Depth-Based Routing (DBR)
  - QELAR

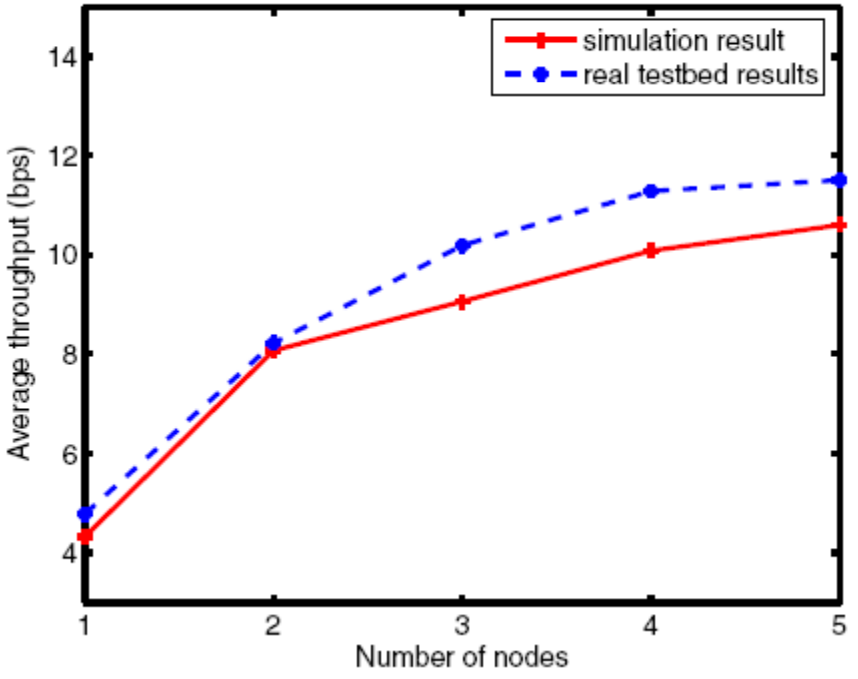
Case Study: Fidelity Testing

- Experiment settings
  - Sending speed: 80 bps
  - Topology:
    - 6 nodes in a one hop network
  - Frame length: 32 bytes
  - Traffic pattern:
    - Exponential distribution

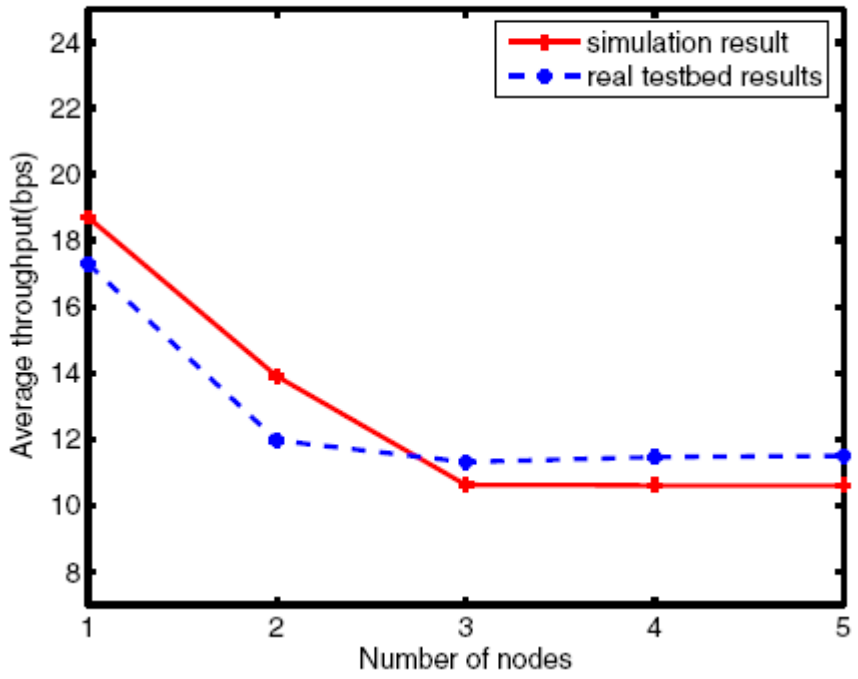


Case Study: Fidelity Testing (cont.)

Throughput with increasing overall traffic
Network load: 0.02 pkt/node/sec



Throughput with fixed overall traffic
Network Load: 0.1 pkt/sec

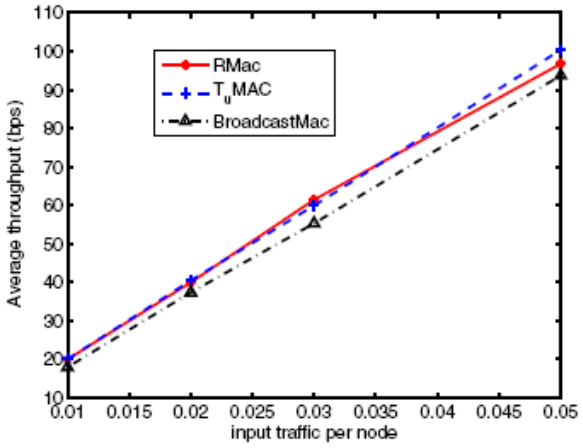


Case Study: MAC protocols

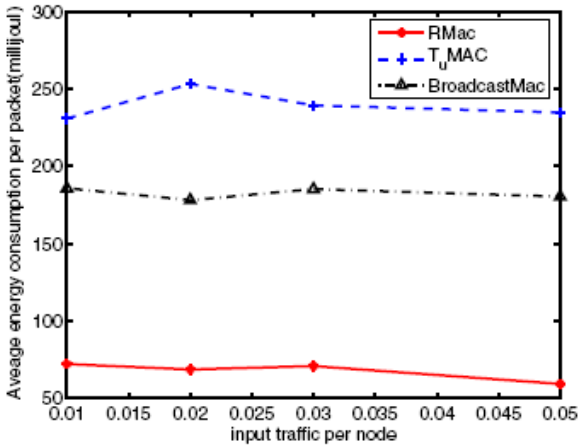
- Experiment settings
  - MAC protocols:
    - R-MAC
    - T_u-MAC
    - Broadcast MAC
  - Packet length 64 bytes
  - Data rate 10 kbps
  - Traffic: 0.01~0.05 pkt/sec

Case Study: MAC Protocols (cont.)

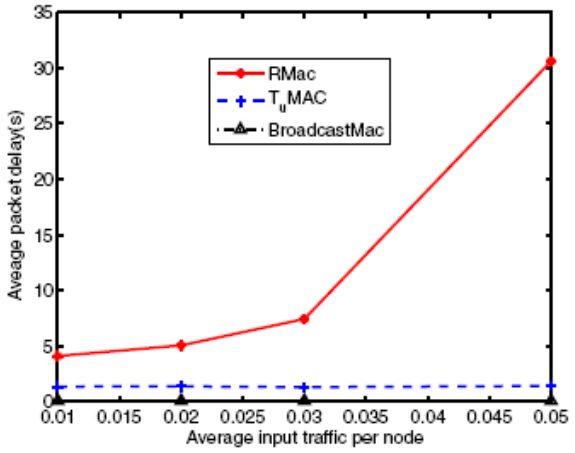
- Metrics
  - Average throughput
  - Average energy consumption per packet
  - Average packet delay



(a) Average throughput



(b) Average energy consumption per packet

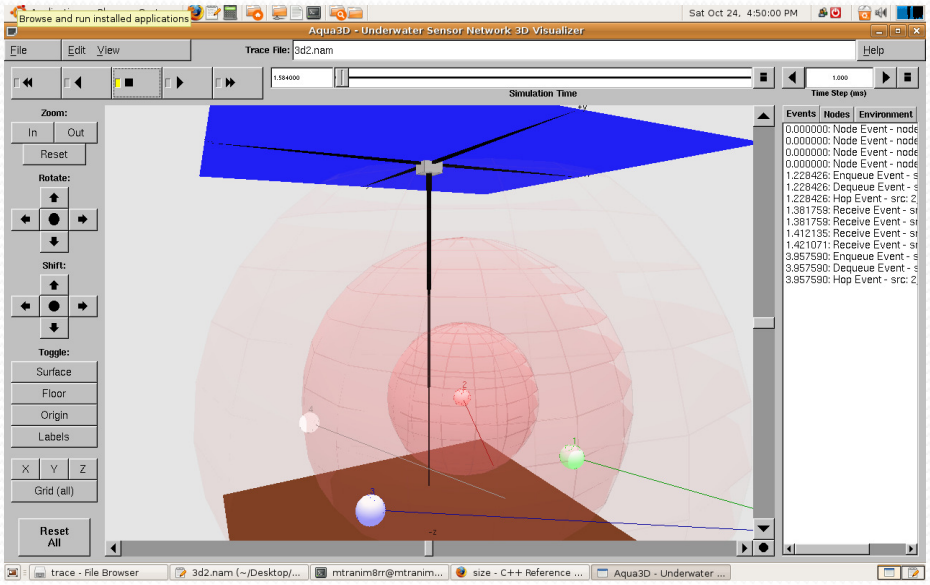


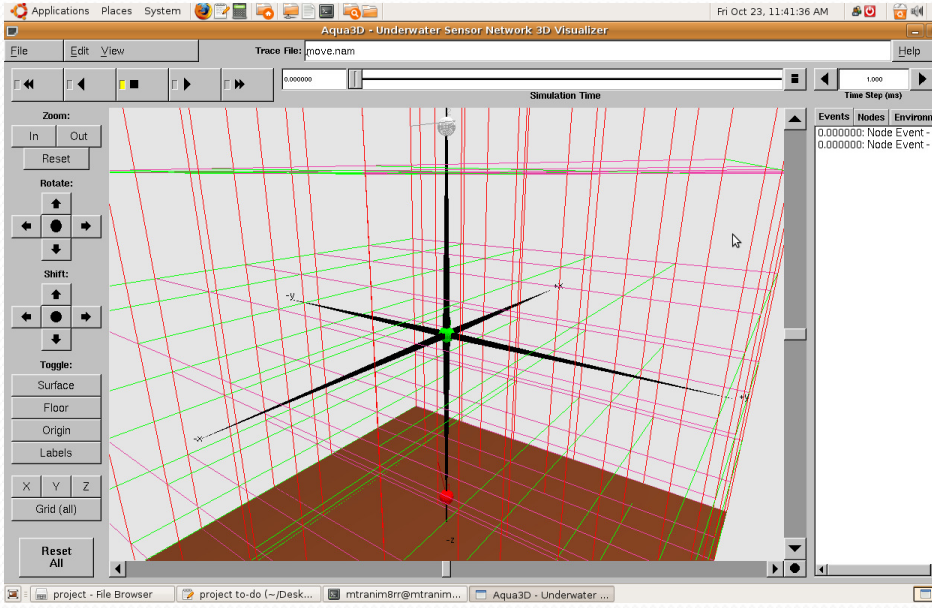
(c) Average packet delay

Conclusions

- Aqua-Sim
  - An extension of NS-2 simulator
  - Specifically designed for underwater networks
  - Support large scale networks
  - Available at
    http://ubinet.engr.uconn.edu/mediawiki/index.php/Aqua-Sim
    http://uwsn.engr.uconn.edu/aquasim.tar.gz
- Future work
  - 3D Animator
  - Advanced channel models
  - More protocols
  - …

Aqua-3D Pictures





Aqua-3D Video

Thanks!