Adaptive Decentralized Control of Underwater sensor Networks for Modeling Underwater Phenomena

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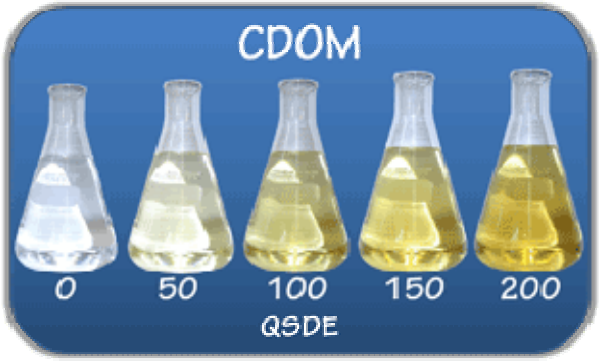
Contents

- Application background
- Aqua nodes
- Depth adjustment
- Field tests
- Conclusions

Modeling underwater phenomena

Background

- Chromophoric Dissolved Organic Matter (CDOM)
  - Remote sensing
  - Estimating light penetration
- Modeling tidal fronts dynamics
  - Measure full volume of the water
  - High density sensors

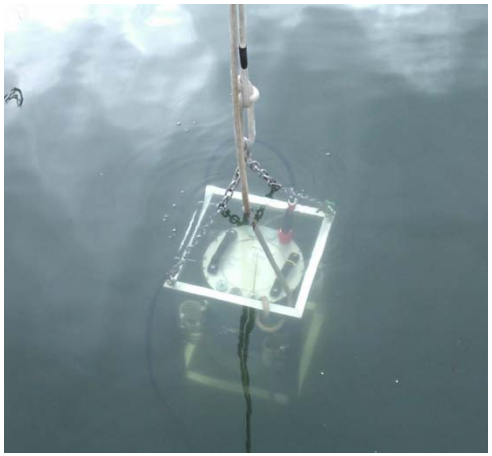


Modeling underwater phenomena

Background

Buoy's

-costs
-static



Column Profiling

-time
consuming

ROV's

-costs
-reliability

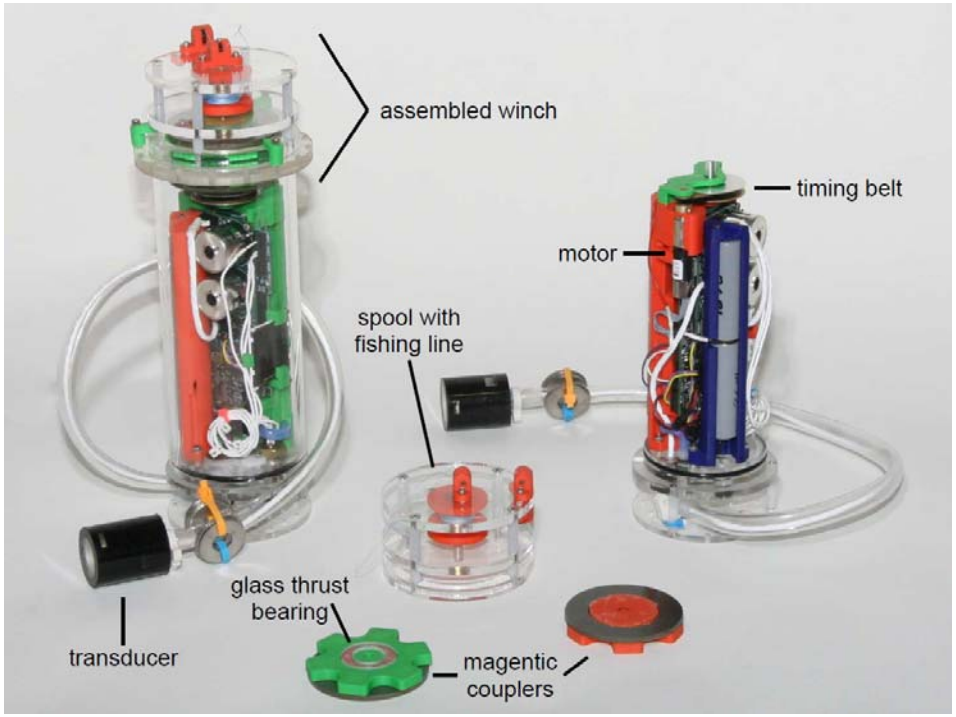
Aqua node

Aqua node

Hardware

- ARM7TDMI @60MHz
- 40kB of RAM and 512kB flash
- SD-cart
- Sensors:
  - CDOM
  - Pressure
  - Temperature
- Winch depth adjustment system

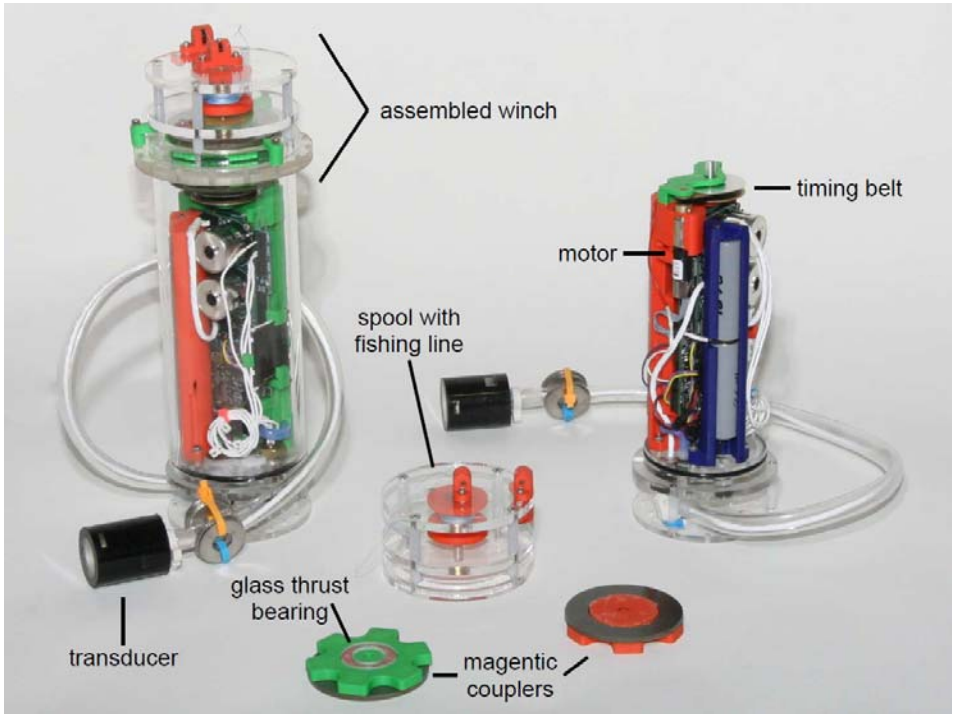
- Cost: €2000



Aqua node

Communication hardware

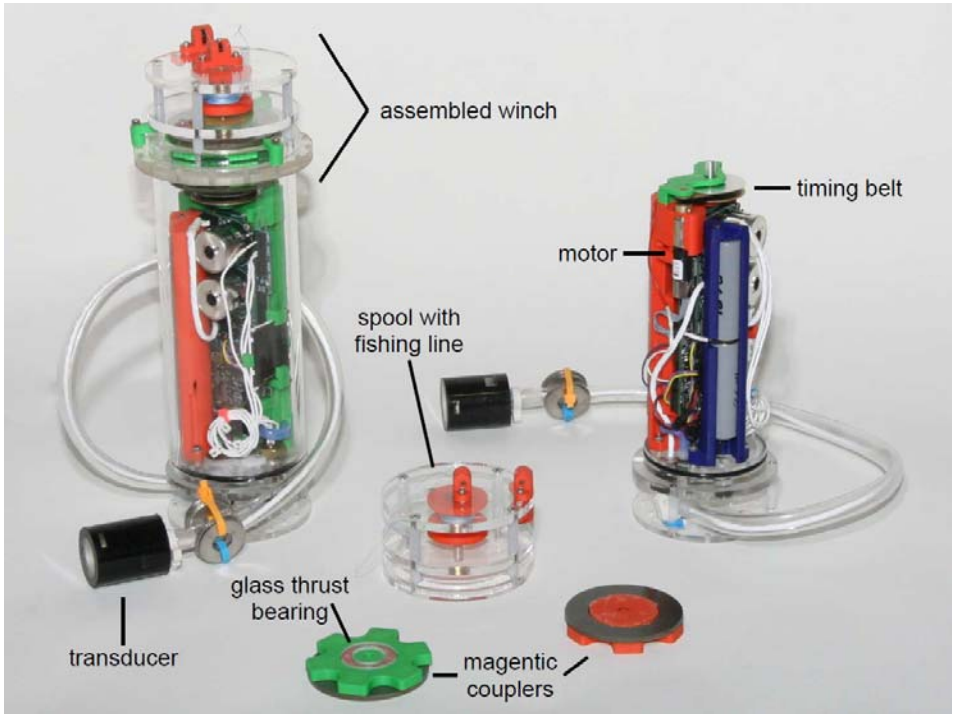
- 10W acoustic modem
  - 300 b/s
  - Self synchronizing TDMA
  - 4 second slots
- Radio communication
  - Only at surface
  - Finding the node



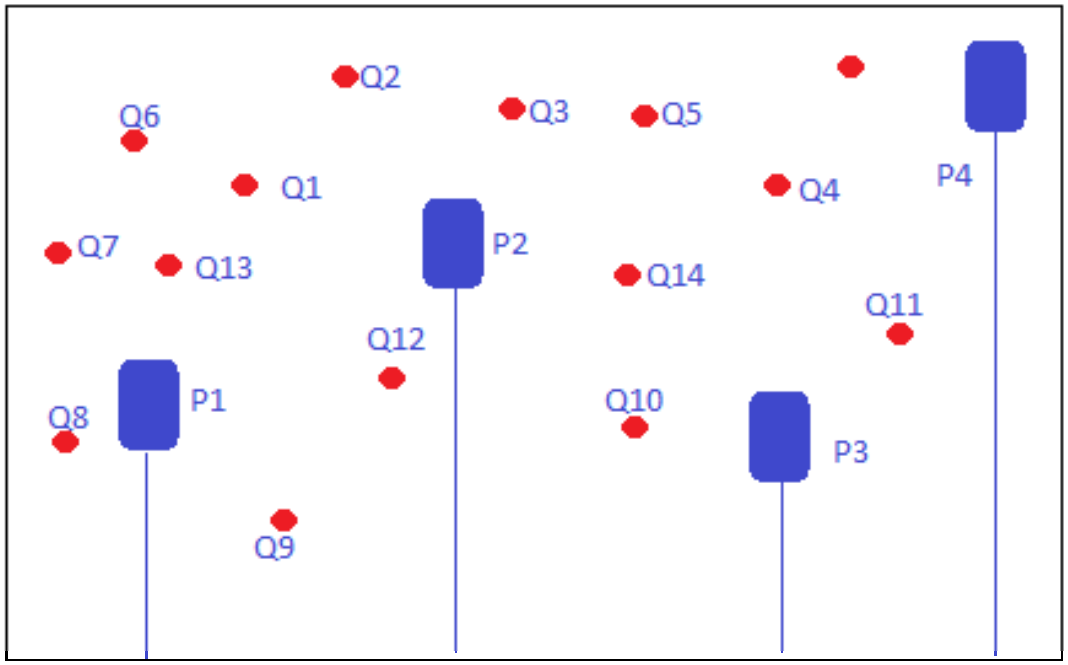
Aqua node

Energy

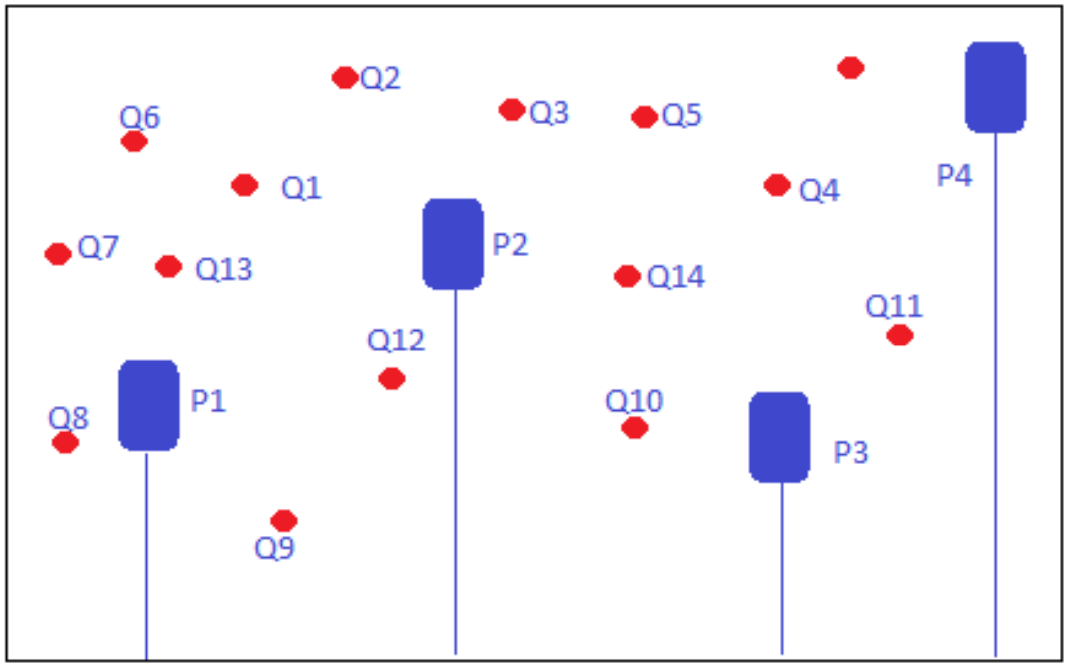
- 60Whr Lithium Ion
- Sleep mode: one year
- Sensing mode: two weeks
- Depth adjustment: 1W



Depth adjustment

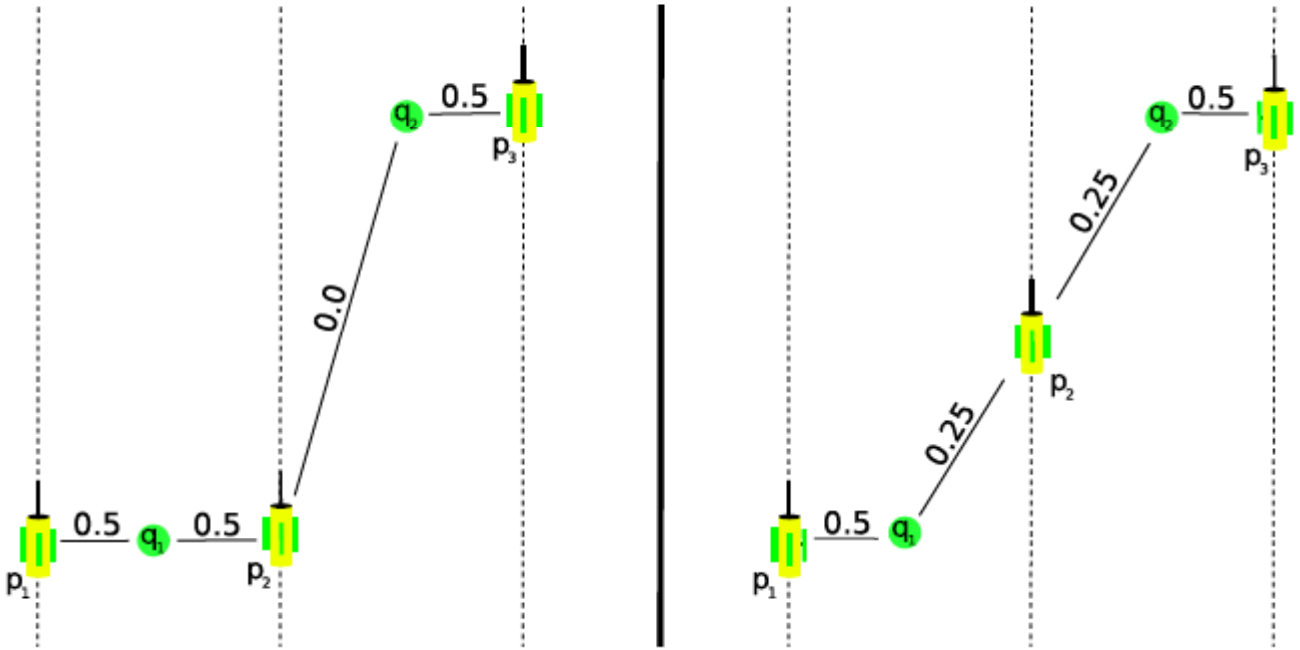


Depth adjustment



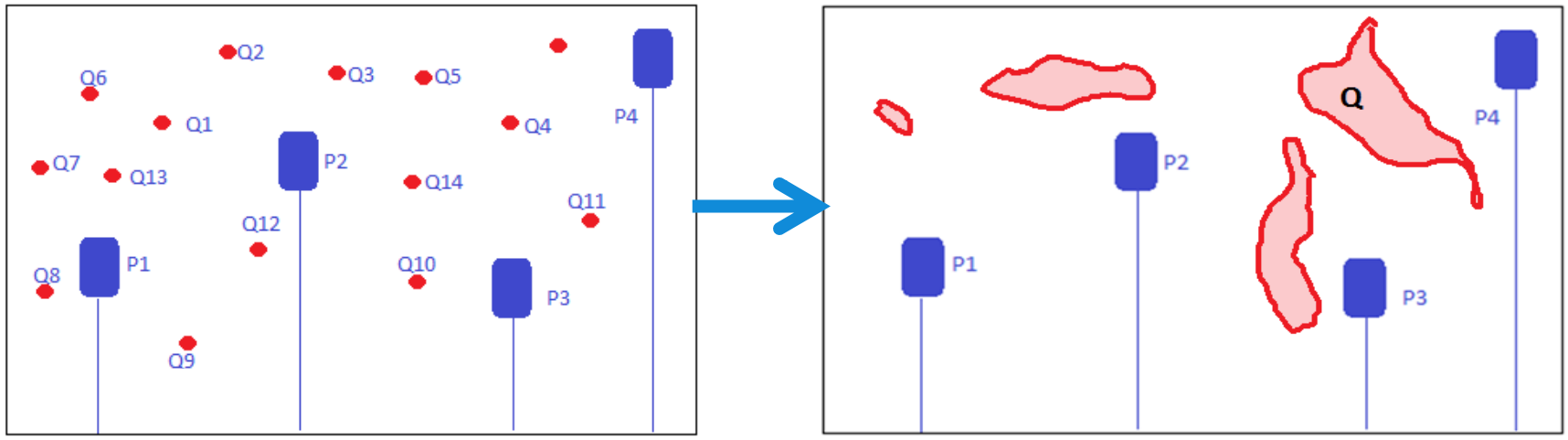
- Maximise: $Cov(p_1,q_1)$
- For all sensors and all points: $\arg\max_{p_i} \sum_{j=1}^{M} \sum_{i=1}^{N} Cov(p_i, q_j)$

Depth adjustment



$$\arg\max_{p_i} \sum_{j=1}^{M} \sum_{i=1}^{N} Cov(p_i, q_j) \rightarrow \arg\max_{p_i} \sum_{j=1}^{M} \left(\sum_{i=1}^{N} Cov(p_i, q_j) \right)^{-1}$$

Depth adjustment



$$\sum_{j=1}^{M}\left(\sum_{i=1}^{N} Cov(p_i,q_j)\right)^{-1} \rightarrow \int_{Q}\left(\sum_{i=1}^{N} Cov(p_i,q)\right)^{-1} dq$$

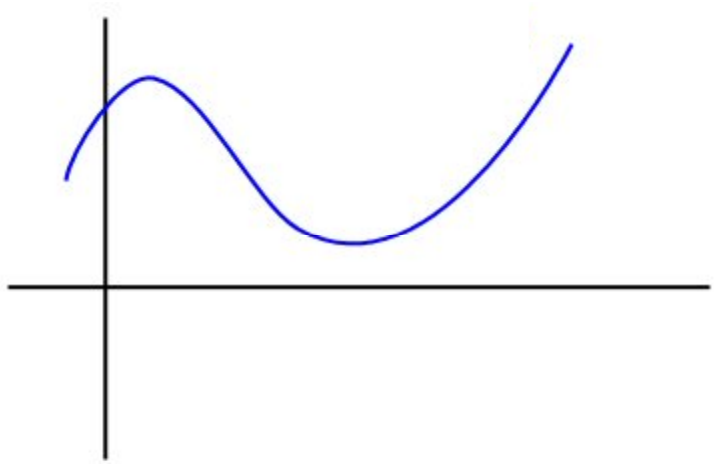
Depth adjustment

The cost function

$$\int_Q \left(\sum_{i=1}^{N} Cov(p_i, q) \right)^{-1} dq$$

- Optimization problem: find the minimum

➢ Differentiate with respect to z axis



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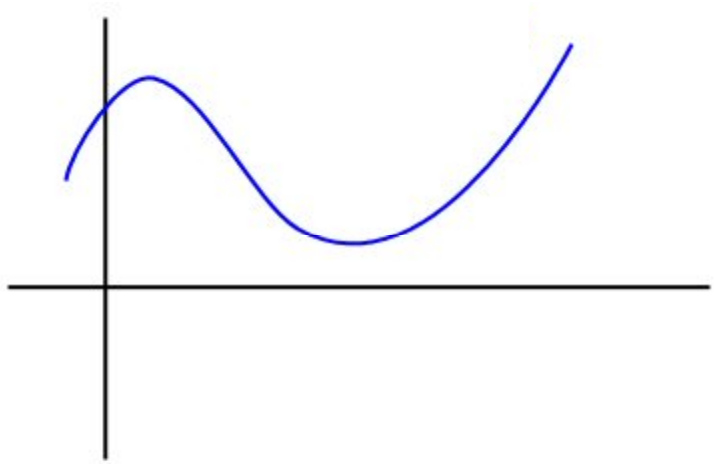


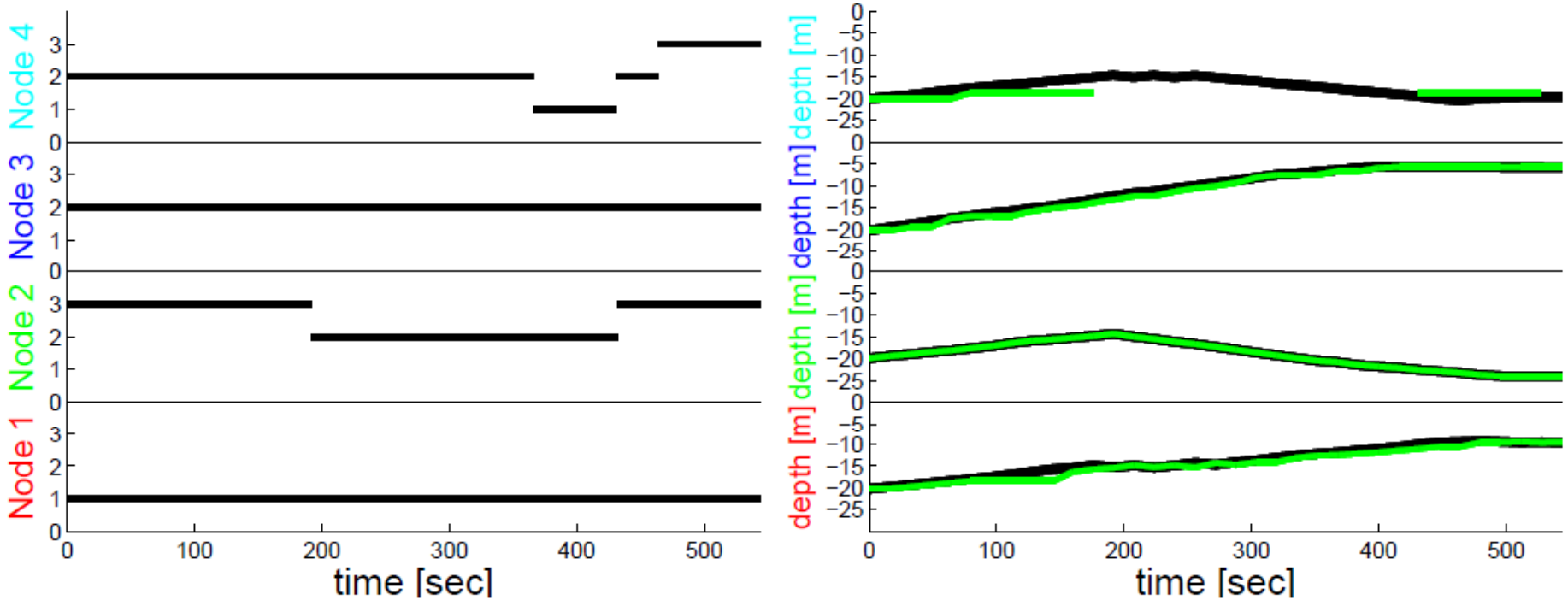
Test results

- Matlab simulation
- Pool
- River

Test results

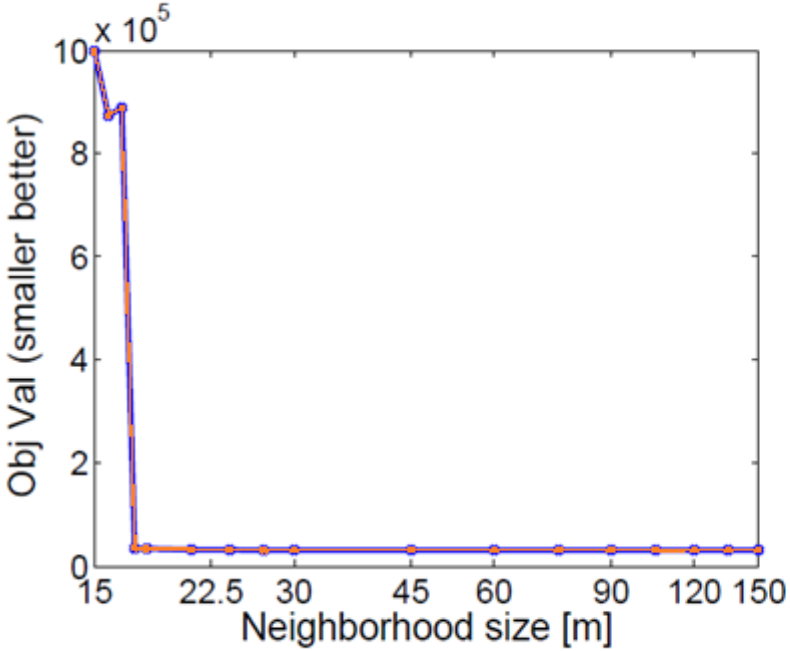
Number of neighbors

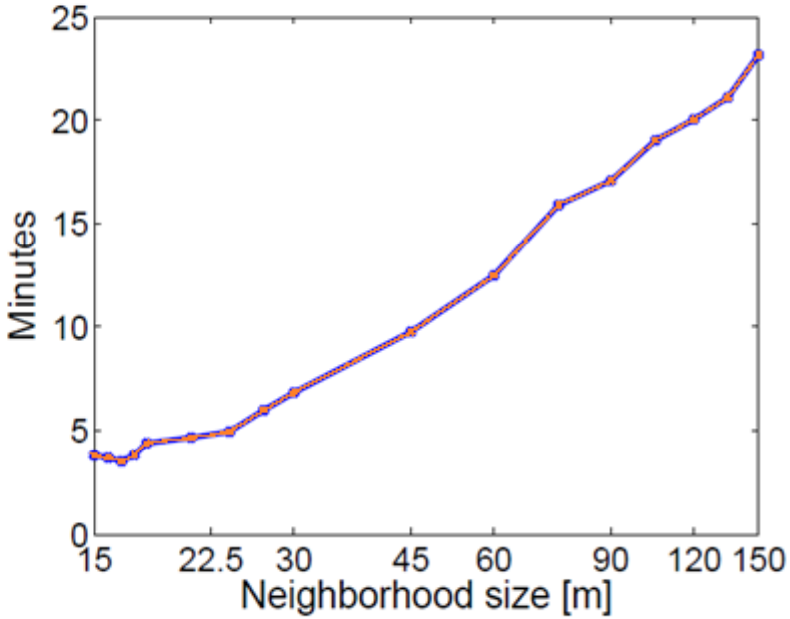
- Each node used information from nodes whose last depth message was received within the past two minutes



Test results

The Neighborhood size

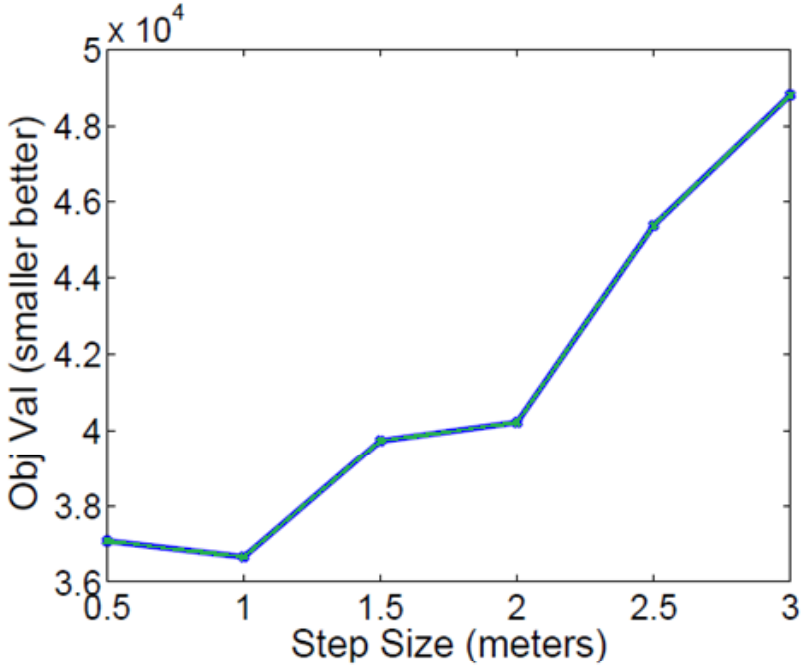


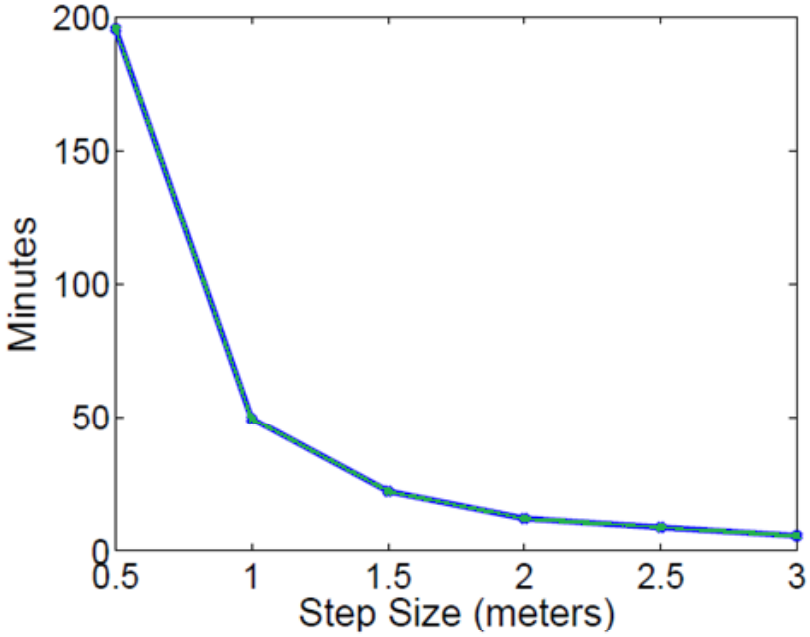


- Simulation: nodes were place 15 meters apart
- Nodes only need to hear direct neighbors for good performance

Test results

The grid size

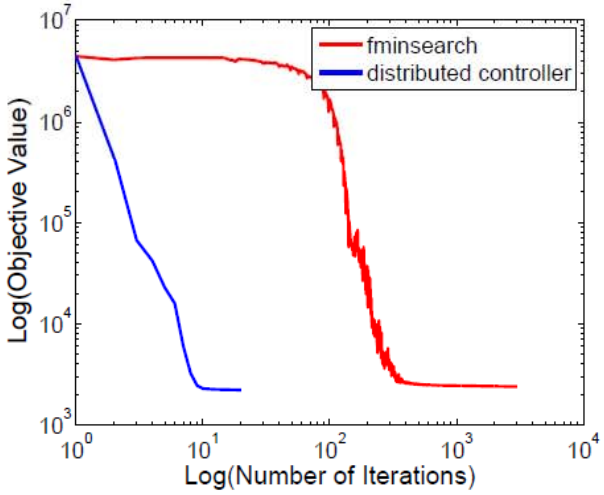


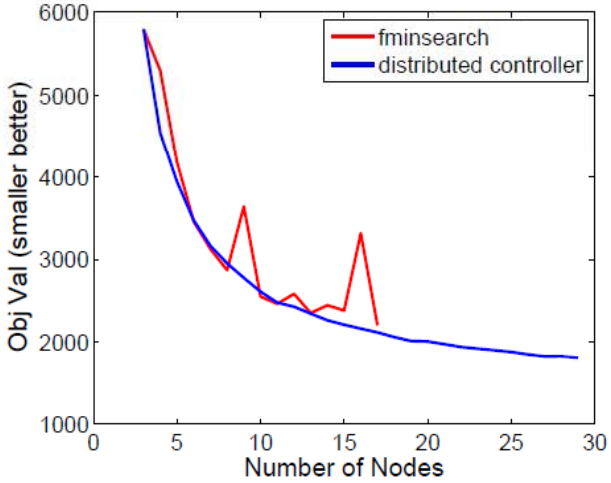


Computation vs. precision

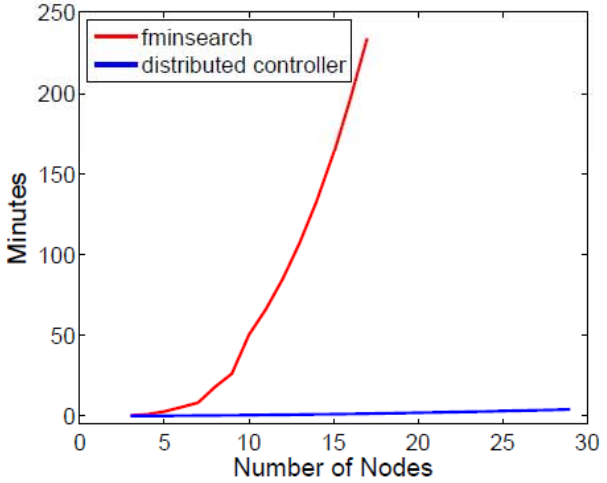
Test results

Controller





(a)



(b)

Conclusions

- Sub marine WSN propose unique challenges
- WSN with depth adjustment enables large volumes analysis of ocean
- Decentralized algorithm to optimize sensor range and communications
- Validated in several field experiments