

# CLAM

## Collaborative embedded networks for submarine surveillance

Hylke W. van Dijk  
Paul Havinga  
University of Twente

## The vision

- Smart Dust....
  - Monitor the environment and object with smart wireless sensors
  - Combination of sensing, distributed processing and wireless communication
  - Ok...., but in water?

# Underwater monitoring applications

- surveillance of coastal borders and harbours
- oil and gas exploration
- earthquake and seaquake prediction
- water environmental monitoring
- water pollution



# Oil and gas exploration and production



# Environmental monitoring

- Global warming
- Pollution
- Biodiversity
- Where?
  - Great Barrier Reef
  - Waddenzee
  - Harbours
  - Oceans



## Objective

- Design and develop a versatile, efficient, and robust underwater monitoring platform
  - Wireless networking
  - Sensing
  - Effective
- Protocols, modeling, architecture, IC, experiments

## Consortium - academia

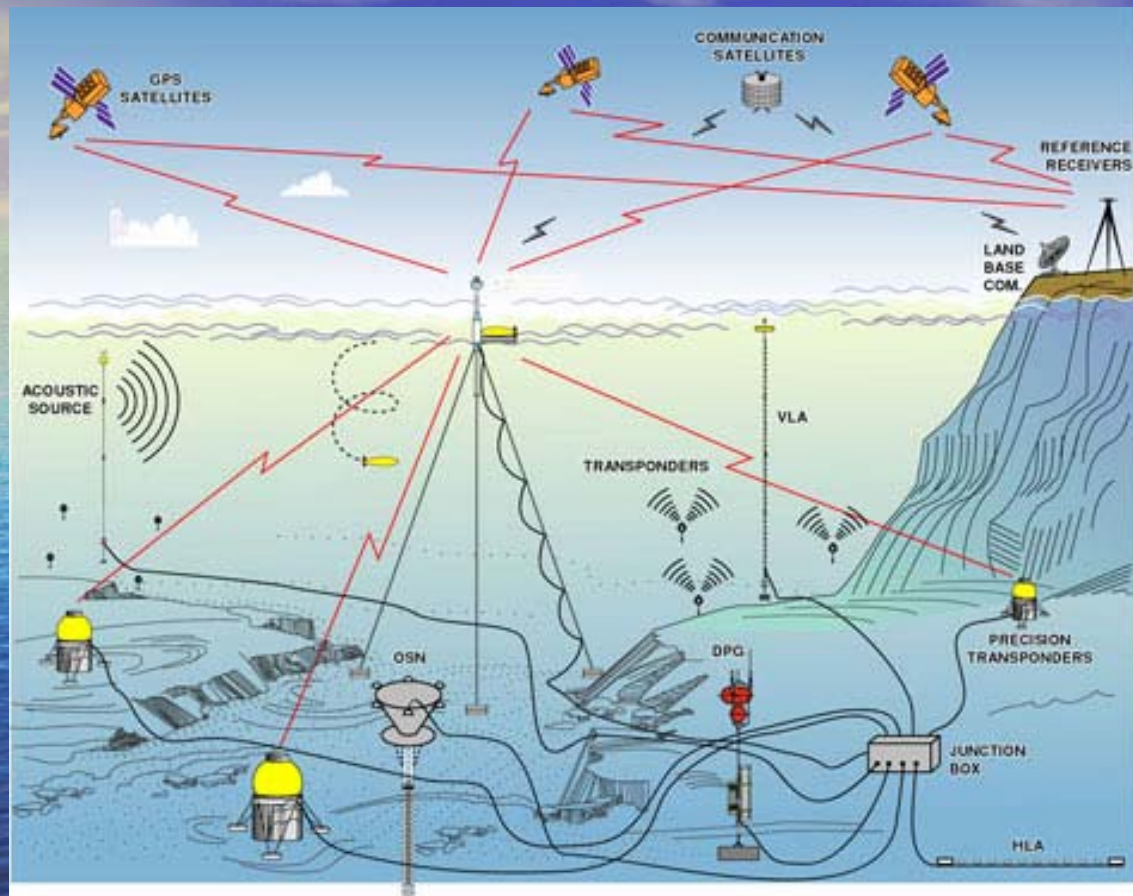
- University of Twente (coordinator)
  - distributed sensing and event detection
- University of Rome "La Sapienza"
  - distributed medium access
  - pollution control and CO2 storage
- University of Padova
  - multi-hop routing protocols
- CINI
  - architecture and system evaluation

## Consortium - industry

- Microflown Technologies
  - acoustic vector sensors (receiver)
  - beamforming
- Kongsberg Maritime
  - acoustic communication (transducer)
  - industrial case studies
- SINTEF ICT
  - underwater channel modeling (PHY)
  - validation and expedition

# State of the art

- Underwater modems
  - Point to point
  - Low data rate, long delays
  - Energy hungry
  - Unreliable
  - Large, bulky, expensive
  - Hard to deploy
- Sensors
  - Expensive
  - High energy consumption
  - Lack of low power acoustic sensors



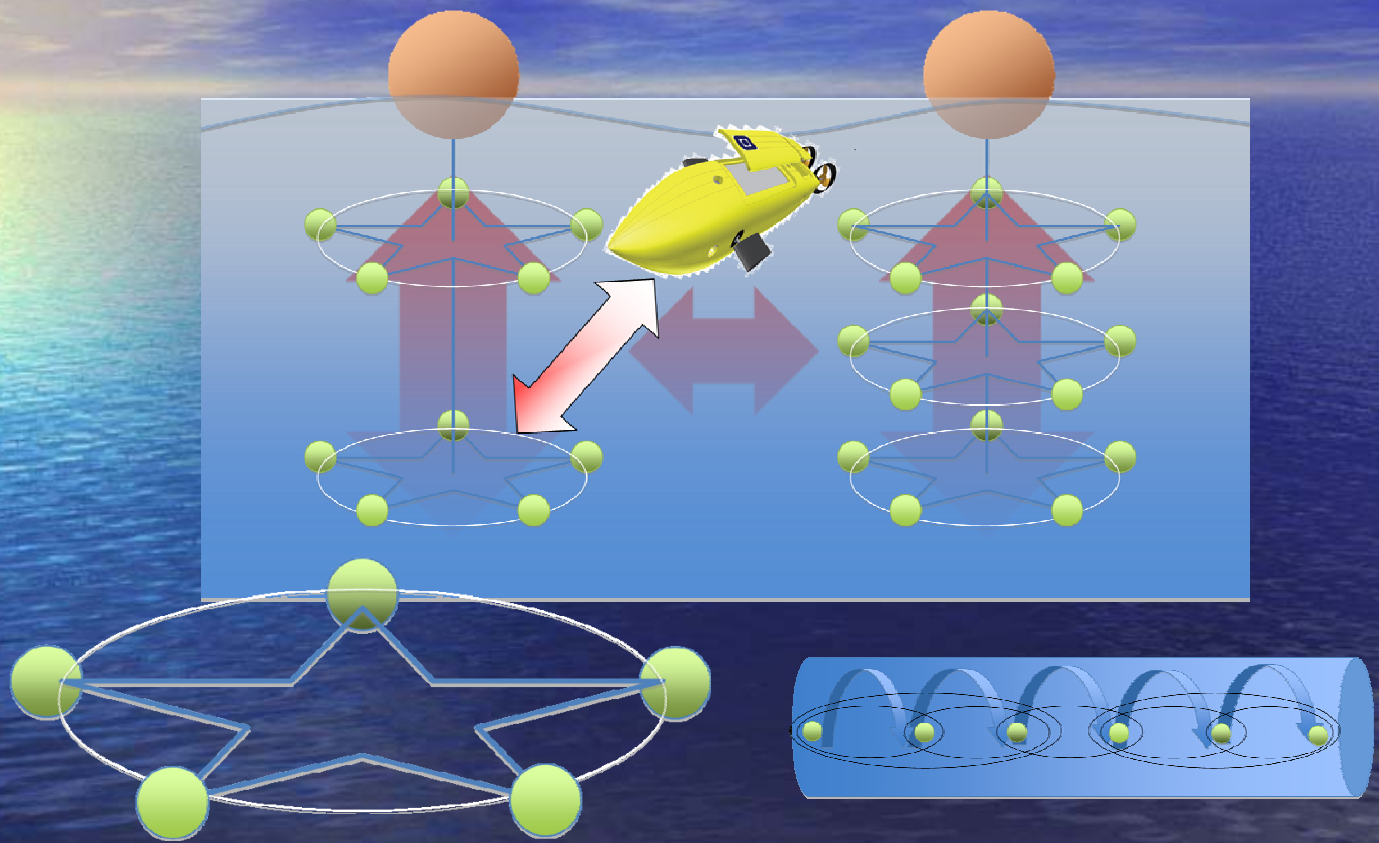
# Research aspects

- Wireless communication
  - Channel modeling
  - Efficient transmission
  - Hybrid underwater networking protocols
- Distributed sensing
  - Low-power acoustic vector sensors
  - Reasoning and data aggregation

# Challenges

- Wireless communication in extremes
  - Latency
  - Multipath
  - Bandwidth
  - Energy
- Harsh environment
  - very dynamic channels
  - floating devices
  - high pressure
- Packaging, operation, and maintenance
- Reliable and versatile sensors

# Hierarchical sensor network



## Low-power acoustic vector sensors for underwater

- Hydroflown, dual functionality
  - passive monitoring acoustic signals and vibrations
  - Active communication receiver
- Packaging and integration



# Efficient communication and information dispersion

- Transducer
  - PHY modeling
  - OFDM modulation
- Communication protocols
  - dynamic MAC protocols
  - Multi-hop routing
- Collaborative networking
  - Beamforming
  - Reasoning and data aggregation

## Conclusions

- A truly multidisciplinary project
- Unexplored research domain
- Lots of challenges
  - Scientific
  - Practical
- International collaboration
  - EU project Hydroflown
  - EU project UAN



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[h.w.vandijk@utwente.nl](mailto:h.w.vandijk@utwente.nl)  
[p.j.m.havinga@utwente.nl](mailto:p.j.m.havinga@utwente.nl)

University of Twente  
Pervasive Systems  
<http://ps.ewi.utwente.nl>