# Sensor Networks for Undersea Seismic Experimentation (SNUSE)

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I-LENSE



CiSoft
CENS

# Why Undersea Sensor Networks?

- Vision: to reveal previously unobservable phenomena (Pottie)
- Goal: to expand senor-net technology to undersea applications
- Numerous potential applications
  - Oilfields: seismic imaging of reservoir
  - Environmental: pollution monitoring
  - Biology: fish or micro-organism tracking
  - Geology: undersea earthquake study
  - Military: undersea surveillance

# Our Focus Application

- Seismic imaging for undersea oilfields
  - Collaborate with USC's ChevronTexaco Center for Interactive Smart Oilfield Technologies (CiSoft)
- Current technology ⟶
  - High cost
  - Perform rarely, about once every 1-3 years

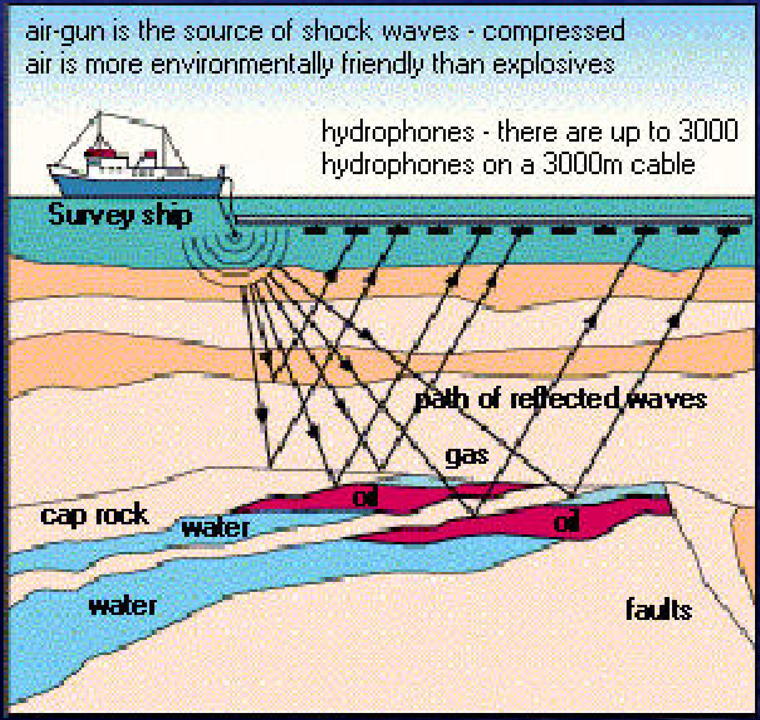
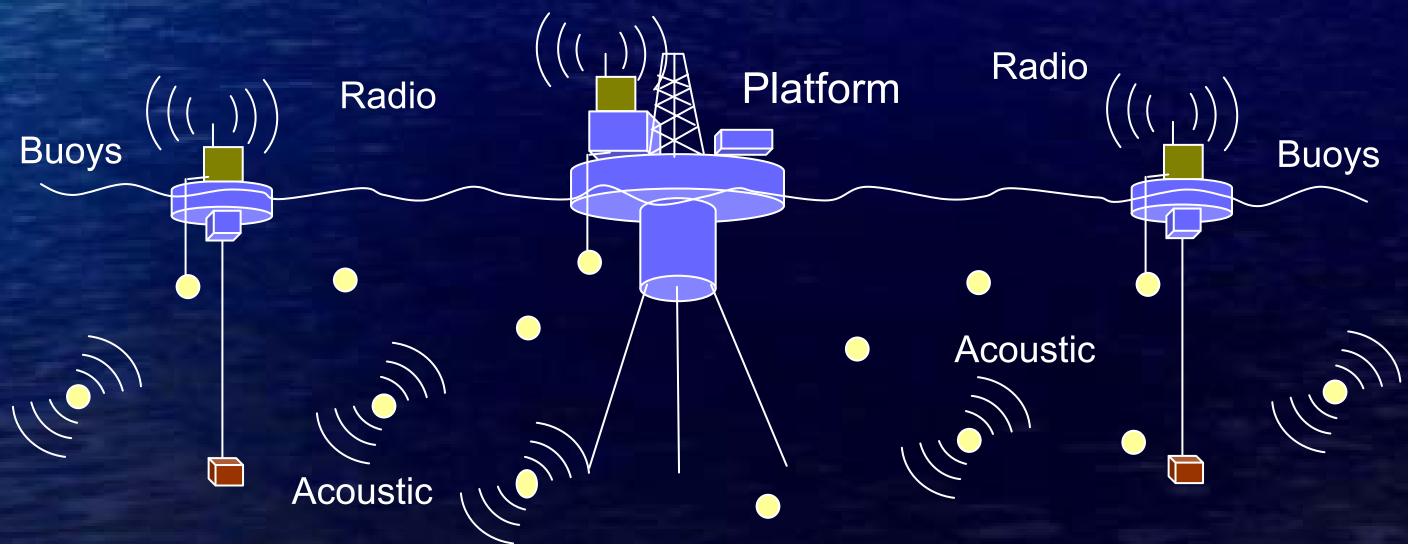



Photo courtesy Institute of Petroleum

# Our Approach: Undersea Sensor Nets

- Dense sensor networks are largely changing terrestrial sensing today
- Bring the concept to undersea environment
  - Enable low-cost, frequent operation
  - Exploit dense sensors, close observation



# Current Undersea Networking

- Sparse networks, small number of nodes, long-range acoustic communication
  - Navy Spawar (Rice): Seaweb network ~20 nodes
  - Woods hole & MIT (Stojanovic)
  - Northeastern Univ. (Proakis)
  - Navy Postgraduate School (Xie)
- Cable networks: high speed, high cost
  - Neptune Network (Several Universities led by Univ. of Washington)
    - 3000km fiber-optic/power cables; $250 million in 5 years
- Instead we focus on low-cost, wireless and dense networks

# Can We Use Current Land Sensor Nets?

- Radios don't directly apply
  - Water significantly absorbs radio waves
    - Mica2's Tx range is ~50cm in water (Sukhatme)
- Can we simply replace radio with acoustic communication?
  - Large propagation delay breaks/degrades many protocols
    - Propagating 200m needs 133ms(1500m/s)
- Need *acoustic communication* and *new networking protocols*

# Acoustic Comm.: Challenges

- Acoustic channel is complex
  - High environmental noise and multi-path fading
  - Low bandwidth
  - Transmission curvature caused by uneven temperature distribution – shadow area
- Low-power transducers/hydrophones
- Existing work
  - Focus on reliability and bandwidth utilization (push to higher bit rates)
  - COTS acoustic modems are long range (1-90km), power hungry and costly

# Acoustic Comm.: Our Approach

- Develop hardware for
  - short-range communication (50—500m)
  - Low-power operation (similar to Mica2 radio)
  - Low data rate (≤10kbps)
- Will take existing results from acoustic communication research
  - Modulation, coding, reliable transmission, etc.
- Short range largely avoids complex channel problems and is the key for low power hardware

# Networking Protocols: Challenges

- Large and varying propagation delay
  - Sound is over 5 magnitude slower than radio
  - Sound speed changes with temperature, depth and salinity
- How does it affect existing protocols?
  - Time sync will break as they all ignores radio propagation delay
  - Fine-grained localization will break as they all depends on radio signal to sync node pairs
  - TDMA needs time sync, and contention MAC could have bad performance

# Networking Protocols: Our Approach

- New time-sync and localization algorithms
  - Estimating the propagation delay is the key for high-precision time synchronization
  - Combine localization with time sync
- MAC protocols suitable for large propagation delay
  - Quantify performance loss with high delay
  - Re-design efficient MACs in high latency networks

# Long-Term Energy Management

- Application only runs once a month
  - Nodes sleep for a month to conserve energy
  - Will investigate new energy management schemes for long sleep time
    - Inspired by work at Intel Portland
- Delay tolerant data transport
  - Large sensor data when application runs
    - 6MB in 5 minutes with 20kHz sampling rate
  - Low-bandwidth acoustic comm. (~10kbps)
  - Will investigate suitable DTN techniques
    - Delay tolerant networking research group (dtnrg.org)

# Summary

- Project goal: expanding sensor-network technology to undersea applications
- Research directions
  - Hardware for low-power, short-range acoustic communications
  - Networking protocols and algorithms suitable for long propagation delay
  - Long term energy management
- Project website

http://www.isi.edu/ilense/snuse