Title
SNUSE Sensor Networks for Undersea Seismic Experimentation

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Authors
Kiran Guaraja
John Heidemann
Yuan Li
et al.

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SNUSE: Sensor Networks for Undersea Seismic Experimentation

Ismail Cevik, Kiran Gururaj, John Heidemann*, Yuan Li, Affan Syed, Jack Wills*, Wei Ye* (* co-PIs)

GOALS:
- Build short range acoustic communication hardware
- Develop delay tolerant, reconfigurable protocols
- Explore new applications and techniques

Overall Architecture
Tiered deployment
- Short range, low-power, dense sensor nodes: acoustic modems underwater
- Optional super-nodes for faster communication: use 802.11 or similar radios on surface

Protocols
What is different than terrestrial sensor nets?
- Propagation latency—the speed of sound
- Sound is 5 orders of magnitude slower than light speed
- Speed varies due to temperature, pressure and salinity
- Need to revisit existing protocols
- High latency breaks many current protocols, like time sync, MAC
- Must validate protocols under different constraints
- Optimize protocols to get better performance in this environment

Time Synchronization for High Latency (TSHL)
Issue:
- Current Time Sync protocols assume:
  - No propagation delay (RBSS, FTSP)
  - No skew during sync. exchanges (TPSN)
  - Both assumptions reduce accuracy when latency grows

Solution: TSHL, new protocol
- TSHL handles these in two phases:
  1. Model skew using beacons – nodes are now skew synchronized
  2. Use the estimated skew in a 2-way exchange to find the skew-compensated offset

Simulation Results:
- TSHL is better than TPSN like protocol at larger distances
- 50% better accuracy at 500m

Scheduled Channel Polling (SCP)-MAC
Goals and Approach:
- Reach ultra-low duty cycles (0.01-0.1%)
- Exploit strengths of LPL and scheduling
- Use LPL-style channel polling for detection of activity
- Use scheduled polling for efficient wakeup and Tx

Experimental Results on Mica2 motes
- LPL consumes 2-2.5 times more energy than SCP-MAC with periodic traffic
- SCP better adapts to varying loads
- Current work is RF-based; expect it to be a component of underwater, high-latency MAC

Applications and Techniques
Applications
- Seismic monitoring of undersea oil fields
- Enable frequent monitoring – 4-D seismic
- Dynamically adjust injection/extraction rates
- Monitor equipment during maintenance and deployment
- Robotic and scientific applications are possible future work

Techniques
- Reconfigure sensor nets after long suspend (hours/weeks)
- Problem: clock skews in 30 days result in more than 2-minute spreading in reboot time
- How to quickly reboot the network in energy-efficient way?
- Two approaches:
  - LPL with first node flooding a network up message
  - Network configuration with request and suppression
- Application level scheduling for optimal data extraction
- Coordinate node operation to reduce interference
- Minimize re-transmissions and extraction time

Acoustic Hardware
Design Goals:
- Short range links (50-300m)
- Multi-hop network
- Omni-directional transducers
- Low energy consumption

Current Status:
- Wake-Up circuit for low powered listening (LPL)
- Designed and prototyped
- 500µW power consumption
- Robotic and scientific applications are possible future work
- Monitor equipment during maintenance and deployment
- Seismic monitoring of undersea oil fields

Why Short Range?
- Low-power transmission and spatial reuse for dense deployment
- Avoid complex problems in under water channels
- 5kbps FSK transmitter
- 30mW power draw in Tx
- Prototyped transmitter for in-air testing

Summary
- Project aims to bring terrestrial sensor-net technology to underwater environment
- Expect to make hardware design and protocol software publicly available
- Papers under submission:

For more information:
http://www.isi.edu/ilense/snuse/

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