SNUSE: Sensor Networks for Undersea Seismic Experimentation

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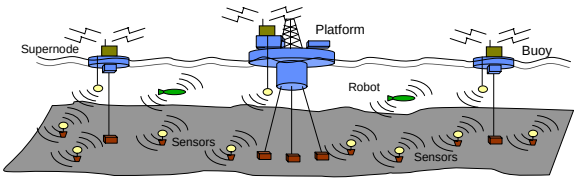
GOALS:

- 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

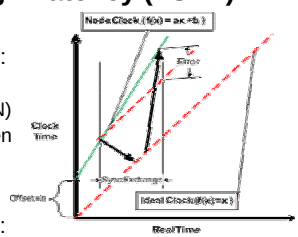
What is different than terrestrial sensor nets?

- 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 (RBS,FTSP)
  - No skew during sync. exchanges (TPSN)
  - Both assumptions reduce accuracy when latency grows

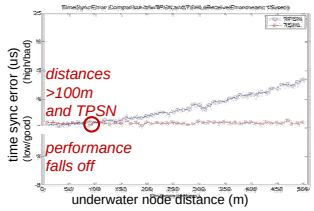


Solution: TSHL, new protocol

- 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:

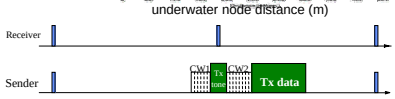
- TSHL is better than TPSN like protocol at *larger* distances
- 50% better accuracy at 500m



Scheduled Channel Polling (SCP)-MAC

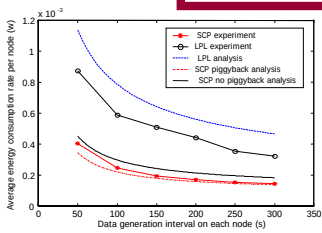
Goals and Approach:

- 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:

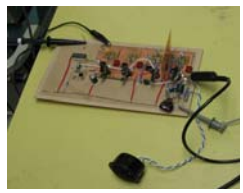
- Short range links (50-300m)
- Multi-hop network
- Omni-directional transducers
- Low energy consumption

Why Short Range?

- Low-power transmission and spatial reuse for dense deployment
- Avoid complex problems in under water channels

Current Status:

- Wake-Up circuit for low powered listening (LPL)
  - Designed and prototyped
  - 500μW power consumption
- 5kbps FSK transmitter
  - 30mW power draw in Tx
  - Prototyped transmitter for in-air testing



Prototype wake-up circuit

Prototype transmitter

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:
  - *Time Synchronization for High Latency Acoustic Networks*, USC/ISI technical report ISI-TR-2005-602.
  - *Underwater Sensor Networking: Research Challenges and Potential Applications*. USC/ISI technical report ISI-TR-603.
  - *Ultra-Low Duty Cycle MAC with Scheduled Channel Polling*, USC/ISI technical report ISI-TR-604.

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

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