# A Two-phase Broadcast Scheme for Underwater Acoustic Networks

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# Applications

Resource exploration

Disaster prevention

Marine animal study

Tactical surveillance

Next: Challenges

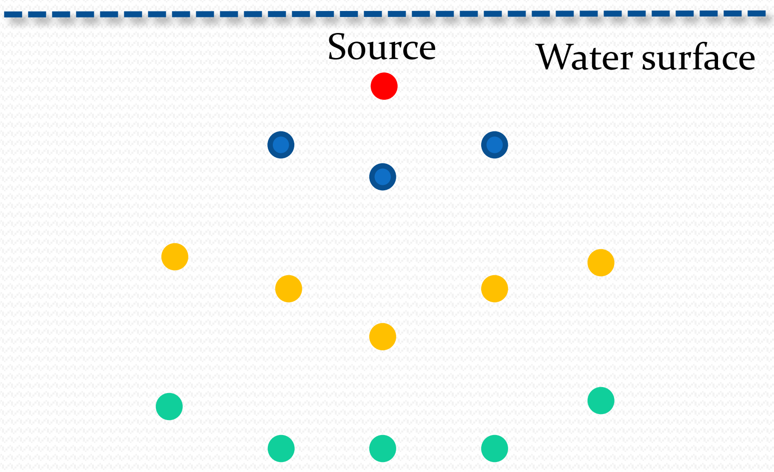
# Challenges

- Acoustic channels
  - Low available bandwidth
  - Long propagation delay
  - High error probability
- High T/S dynamics
  - Link quality
  - Network topology
- Hardware constraints
  - Half-duplex acoustic modems
  - Battery powered nodes

Next: Broadcast service in UAN

# Reliable and Efficient Broadcast

- A critical service for UANs
  - Network wide file distribution
  - OS update
- Requirements:
  - Reliability
    - 100% packet delivery ratio
  - Efficiency
    - Time efficiency
    - Energy efficiency




Next: Road map

# Roadmap

- Existing Approaches
- TBS Overview
- Fast Spreading Phase
- Data Recovery Phase
- Simulation Results
- Summary and Future Work

# Existing Approaches

- Broadcast in Ad-hoc networks
  - Fixed probability based approaches:

    -- Lack adaptability
  - Neighbor or topology information based:

    -- Difficulty to obtain and maintain neighbor information

    -- Large overhead with message exchanges

- Broadcast in UANs
  - Hop by hop advancement

    -- Bottleneck link decides per-hop broadcast completion time
  - Overlooks overhearing opportunities

    -- Up to 3 rounds of overhearing

Next: TBS overview

# TBS Overview

- Fast Spreading phase: efficiency
  - Opportunistic overhearing + network coding
- Data Recovery phase: reliability
  - A hybrid-ARQ approach

- System model
  - Half duplex modem
  - Transmission delay $D_{tx} = L_{pre} + \frac{8L}{R}$
  - Decoding delay $D_{de} = \frac{0.17NL}{80}$
  - Propagation delay $D_{pr} = \frac{D}{V}$

Next: TBS fast spreading

# Fast Spreading Phase

- Objectives
  - Alleviate broadcast storm: whether to rebroadcast
  - Reduce collision probability: when and how many to rebroadcast
- Whether to rebroadcast
  - $P_R = \frac{K\prime}{K} e^{-\frac{p_i - p_r}{p_i}}$ (K': number of linearly independent packets accumulated)
  - Factor 1: number of accumulated packets
  - Factor 2: power constraint
  - No need for topology or neighbor information

Next: How many and when?

# Fast Spreading Phase

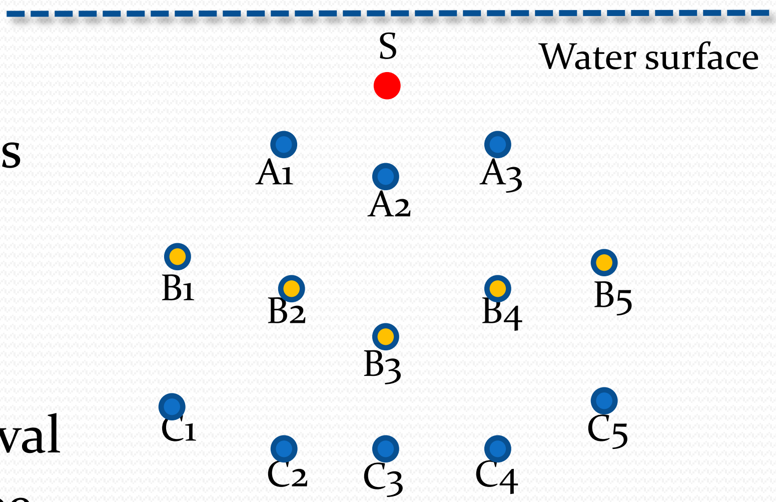
- How many to rebroadcast
  - Uniformly K encoded packets
  - For a forwarder with K' linearly independent packets

    -- regenerate (K-K') encoded packets
- When to rebroadcast
  - $T_{BF} = D_{de}\lceil MP_e \rceil$

    -- $D_{de}$: decoding delay for K packets

    -- M: maximum back-off number

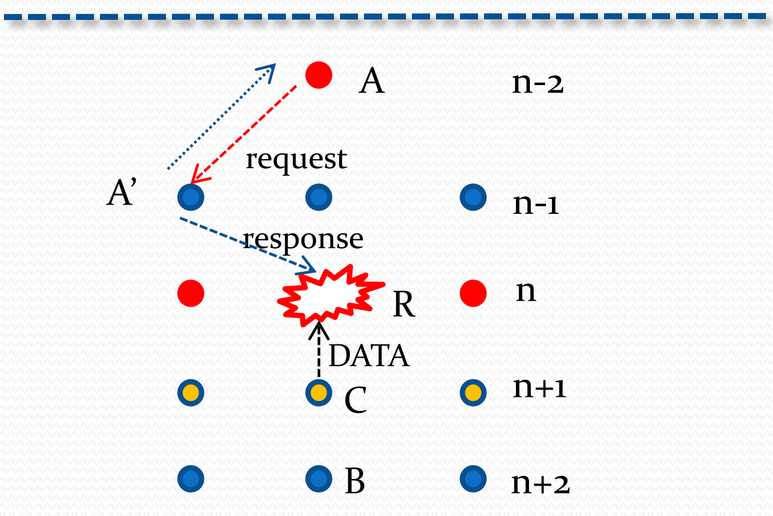
    -- $P_e$: [0,1] uniform distribution
  - A1, A2 and A3 waits 0,1 and 2 $D_{de}$
  - 3 blocks arrive at B3 with $D_{de}$ as interval
  - Enough for decoding and collision free
  - Cannot guarantee zero collision but can reduce it




Next: TBS data recovery

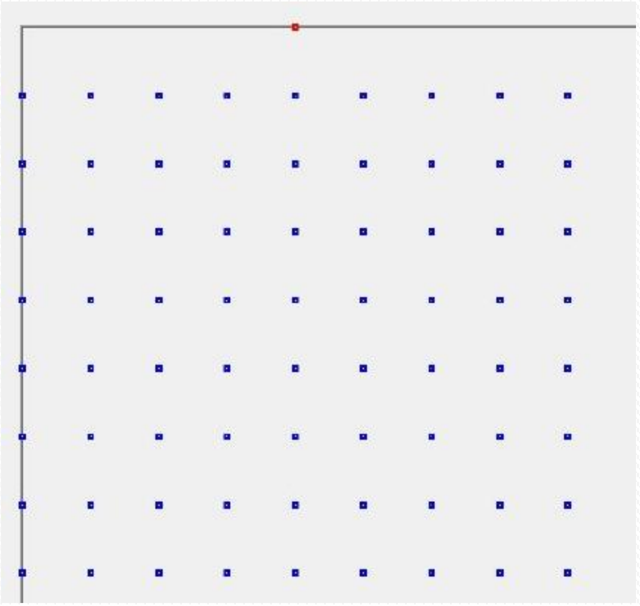
# Data Recovery Phase

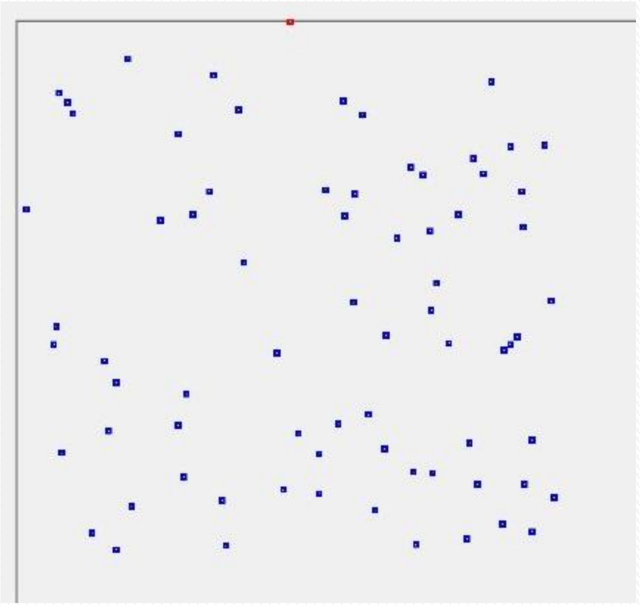
- Data Recovery happens when a node fails to recover all the *K* original data packets in the first phase.
- A hybrid ARQ procedure
  - A node sends request
  - Neighbors coordinate to respond
- Interference with Fast Spreading
  - Delays sending request until nodes within 3 hops finish fast spreading
  - $T_{BD} = 4(D_{tx} + D_{pr} + MD_{de})$




Next: Simulation settings

# Simulation Setting

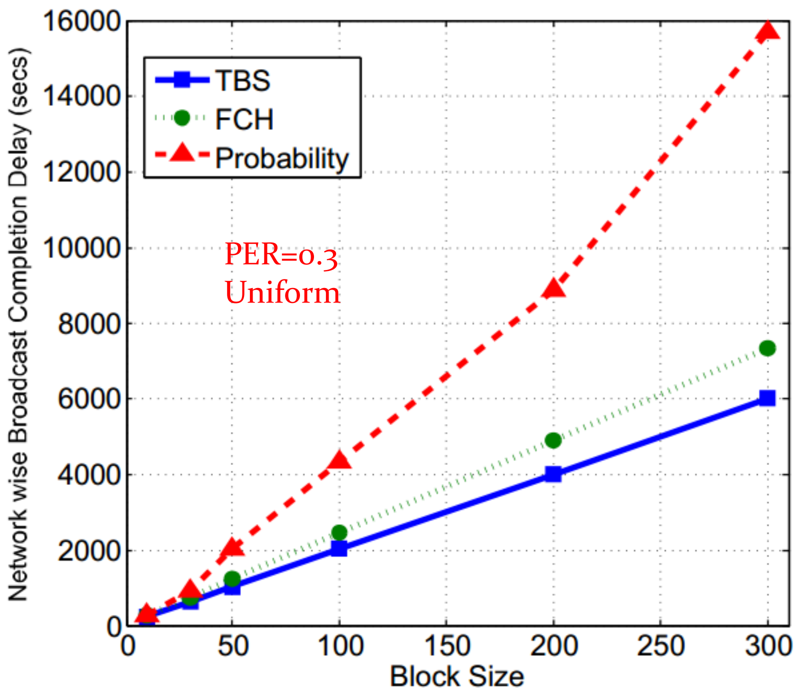


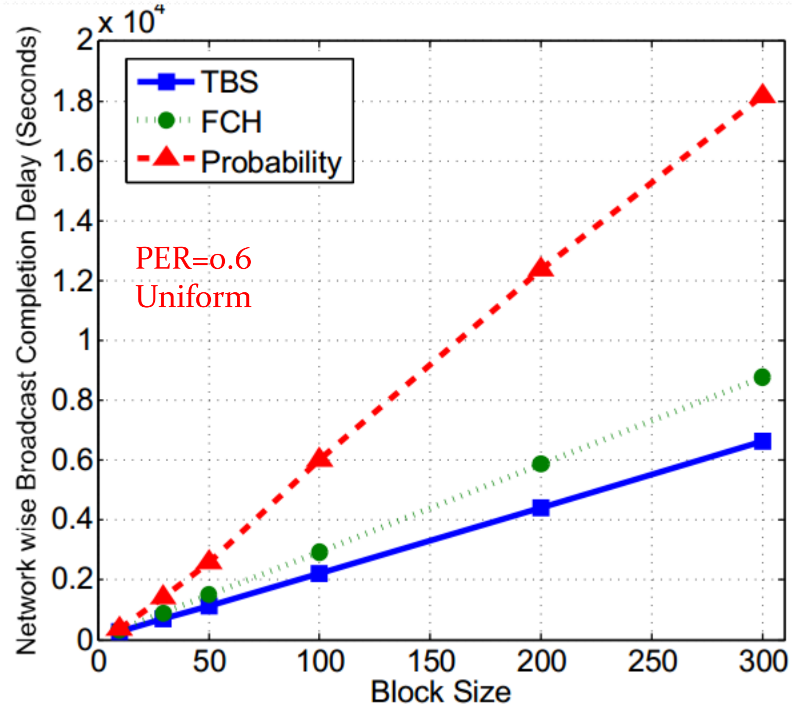


- Uniform and random topology with 73 nodes
- Packet length: 80 bytes
- Decoding delay (modem block): 170 milliseconds
- Distance: 1500 meters

Next: Result – completion time

# Broadcast Completion Time

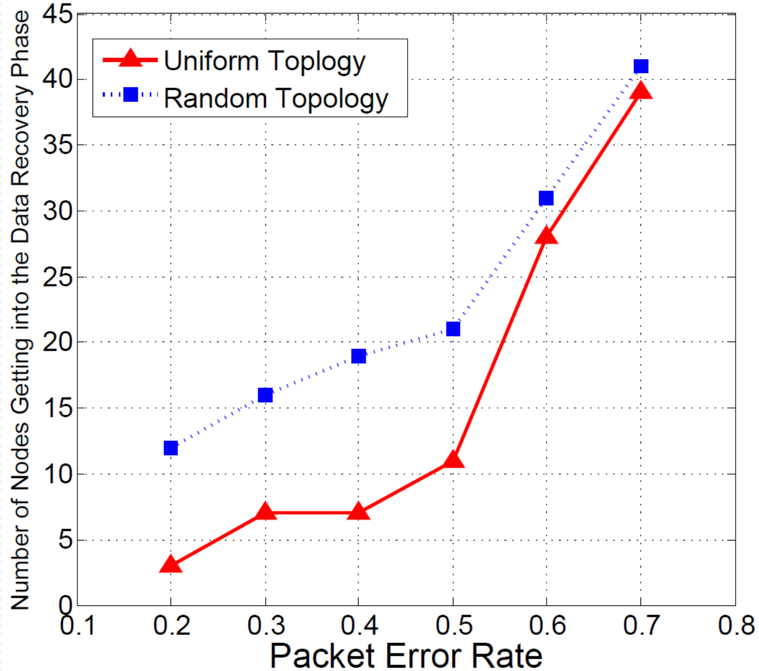


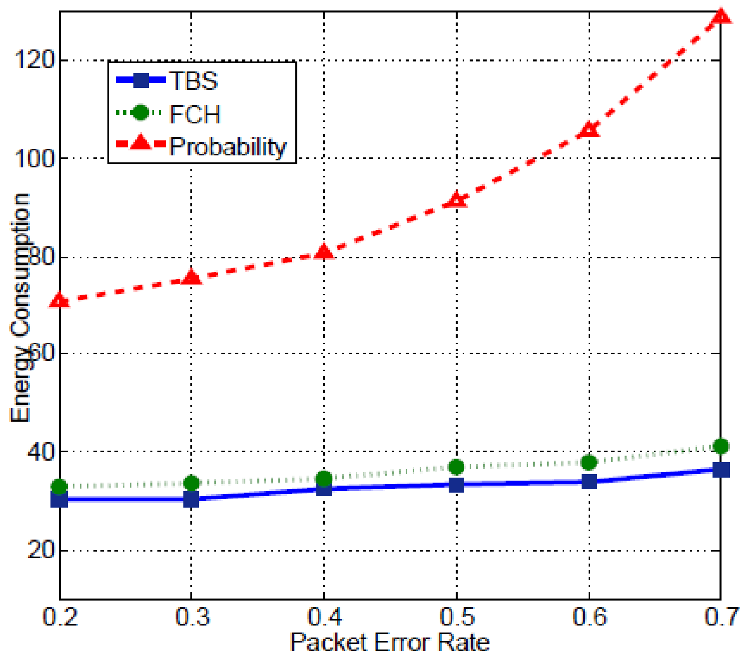




- Network wide broadcast completion time
- Compared with
  - FCH: FEC coding based hop-by-hop advancement
  - Probability: pure probability based method
- Topology: random
- PER: low and high

Next: More results

# More Simulation Results




Number of nodes into the Data Recovery phase

Energy consumption

Next: Conclusions

# Summary and Future Work

- TBS: Two-phase Broadcast Scheme
- Fast Spreading phase
  - Combines opportunistic overhearing and network coding
  - Alleviates broadcast storm and reduces collision
- Data Recovery phase
  - Guarantees reliability
  - Minimizes interference
- Future work
  - More effective scheduling algorithm (maximum back-off number)
  - Lab tests and field tests

Thanks

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Questions?