WTE-MAC: Wakeup Time Estimation MAC for Improving End-To-End Delay Performance in WSN

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Summary

• Motivation

• Previous Schemes: B-MAC, X-MAC

• Proposed Enhancement: Synchronization at the Neighbor's Duty Cycle (SND)

• Proposed Enhancement: Virtual Tunnels (VT)

• Simulations

• Conclusions
Motivation

• Applications
  • Event monitoring
  • Military intrusion detection
• Very light traffic scenario
• Bursty traffic when it occurs

• Requirements
  • Very low power consumption (long operation time)
  • Low end-to-end delay on event

Source: http://www.agentvi.com/21-Solutions-74-Critical_Infrastructure_Govt
Motivation

- Energy efficiency important
- Contention-based protocols
- Duty cycling

<table>
<thead>
<tr>
<th>Synchronous CB protocols</th>
<th>Asynchronous CB protocols</th>
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<tbody>
<tr>
<td>S-MAC, T-MAC</td>
<td>B-MAC, X-MAC</td>
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<tr>
<td>• Duty cycle's phase synchronized</td>
<td>• Nodes not aware of duty cycle's phase of other nodes</td>
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<tr>
<td>• Control packets for synchronization (SYNC)</td>
<td>• No synchronization overhead</td>
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<tr>
<td>• Less energy efficient</td>
<td>• Best energy efficiency</td>
</tr>
<tr>
<td>• Low end-to-end delay</td>
<td>• But: high end-to-end delay</td>
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• Lee et al.: can we join the best of both worlds?
Problem Statement and Approach

• Develop contention-based MAC algorithm having
  • Low power consumption
  • Low end-to-end delay

• Low power consumption achieved by basing proposed algorithm on an asynchronous algorithm (X-MAC)
  • No SYNC packets overhead

• Low end-to-end delay achieved by
  • Using the asynchronous algorithm's packets themselves (preambles) for synchronization – SND
  • Creating virtual connections for transmitting data bursts – VT
Previous Schemes: B-MAC, X-MAC

**B-MAC**
- Preamble sampling

**X-MAC**
- Short Preamble sampling
- Early ACK

Synchronization at the Neighbor's Duty Cycle (SND)

• Basic scheme works just like X-MAC
  • Short preamble sampling
  • Early ACK

• Short preambles contain synchronization information
  • Retransmission Interval (RI)
  • Retransmission Count (RC)
  • Duty Cycle Duration (DD)

• Receiver estimates duty cycle phase from this information and thereby synchronizes to sender
  • Neighbors get synchronized after data transmission
Synchronization at the Neighbor's Duty Cycle (SND)
Virtual Tunnel (VT)

- Designed for efficient transmission while
  - Data is sporadic and in bursts
  - Transfers are multi-hop
- Circuit established from source to destination
  - Uses ACK packets for establishing circuit without overhead
  - Forwarding is not changed while circuit is present
  - Circuit released after burst

- Scheme reduces end-to-end delay
Virtual Tunnel (VT)

- All nodes synchronize to the same original transmitter (node C)
- RC count keeps increasing through hops
- Every node compensates for synchronization mismatches caused by ACK packets
Simulations

- Networks

- Routing: AODV (grid), flooding (linear)

- Interference, CCA, communication range
  - 680 meters, 280 meters, 200 meters

Source: http://www.st.ewi.tudelft.nl/~koen/wnsn/2012/lecture2.pdf
Simulations

- Grid network
- End-to-end delay reduced w.r.t X-MAC
  - Due to synchronization with the VT mechanism
  - More significant on longer distance (multi-hop) and higher bitrate communication
- Energy consumption reduced w.r.t. X-MAC
  - Less short preamble transmissions and idle listening

(a) End-to-end latency as hop (Grid)
(b) End-to-end latency as traffic (Grid)
(c) Energy consumption as traffic (Grid)
Simulations

- Linear network
- Similar picture
- Slightly better performance due to lower neighboring interference
Conclusions

• Proposed enhancements for an asynchronous contention-based MAC protocol for Wireless Sensor Networks (X-MAC)

• Low end-to-end delay without SYNC overhead (synchronous protocols)

• Keeps (even improves) low power consumption of asynchronous protocols

• Virtual Tunnels for bursty traffic

• Applications: event monitoring, military intrusion
Conclusions

• Other approaches achieving low power, low delay

• Wireless Sensor MAC (WiseMAC) (El-Hoiydi et. al)
  • Preamble sampling, no early ACKs (listening feedback)
  • Sender learns timing from receiver through (data) ACKs
  • SND: receiver learns timing from sender through preambles
  • Bursts through 'frame pending bit'

• Opportunistic Routing in WSN (Landsiedel et. al.)
  • Anycast routing (many potential receivers)
  • Consensus protocol for choosing forwarder
Questions