MMSN: Multi-Frequency Media Access Control for Wireless Sensor Networks

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Outline

• Introduction
• MMSN protocol
  – Frequency Assignment
  – Media Access Design
• Performance Evaluation
• Conclusions
Introduction

• Motivation
  – RTS/CTS are too heavyweight for WSN
  – due to small packet size: 30~50 bytes in WSN vs. 512+ bytes in MANET

• MMSN is the first multi-frequency MAC, specially designed for WSN, where single-transceiver devices are used
MMSN protocol

- **Frequency Assignment**
  - **Exclusive Frequency Assignment**
    - Each node knows its two-hop neighbors’ IDs
    - The smallest ID choose first (choose the smallest available)
MMSN protocol

- **Even Selection**
  - Choose one of the least chosen frequencies
  - Needs a number of two-hop broadcast

- **Eavesdropping**
  - Take a random backoff before broadcast frequency decision
  - only collect information within one hop for decision
    - more conflicts
  - Only broadcast to one hop neighbors
    - less communication overhead
## MMSN protocol

<table>
<thead>
<tr>
<th>#frequencies $\geq$ #nodes within two hops</th>
<th>#frequencies $&lt;$ #nodes within two hops</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exclusive Frequency Assignment</strong></td>
<td><strong>Even Selection</strong></td>
</tr>
<tr>
<td>• guarantee that nodes within two hops get different frequencies</td>
<td>• Balance available frequencies within two hops</td>
</tr>
<tr>
<td></td>
<td>• The left scheme has fewer potential conflicts</td>
</tr>
<tr>
<td></td>
<td>• The right one has less communication overhead (energy-efficient)</td>
</tr>
</tbody>
</table>

**Eavesdropping**
MMSN protocol

• Media Access Design
  – Maximize parallel transmission
  – One specific frequency is used for broadcast ($f_0$)
  – Time is divided into slots

Compete for the same broadcast frequency

Compete for unicast frequency
MMSN protocol

- Case 1: Has no packet to transmit

Sensing until $T_{PacketTransmission}$
MMSN protocol

– Case 2: Has a broadcast packet to transmit

\[ T_{bc} \quad T_{trans} \]

(a) Back off \((f_0)\) \(\xrightarrow{\text{Signal}(f_0)}\) Receive BC \((f_0)\)

(b) Back off \((f_0)\) \(\xrightarrow{\text{Send broadcast packet}(f_0)}\)
MMSN protocol

- Case 3: Has a unicast packet to transmit
MMSN protocol

– Toggle snooping
  • During “back off \((f_{self}, f_{dest})\)“, toggle snooping is used
Performance Evaluation

• Simulation Configuration
  – GloMoSim

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>TERRAIN</td>
<td>(200m×200m) Square</td>
</tr>
<tr>
<td>Node Number</td>
<td>289</td>
</tr>
<tr>
<td>Node Placement</td>
<td>Uniform</td>
</tr>
<tr>
<td>Application</td>
<td>Many-to-Many/Gossip CBR Streams</td>
</tr>
<tr>
<td>Payload Size</td>
<td>32 Bytes</td>
</tr>
<tr>
<td>Routing Layer</td>
<td>GF</td>
</tr>
<tr>
<td>MAC Layer</td>
<td>CSMA/MMSN</td>
</tr>
<tr>
<td>Radio Layer</td>
<td>RADIO-ACCNOISE</td>
</tr>
<tr>
<td>Radio Bandwidth</td>
<td>250 Kbps</td>
</tr>
<tr>
<td>Radio Range</td>
<td>20m~45m</td>
</tr>
</tbody>
</table>
Performance Evaluation

- Different traffic pattern
  - 50 CBR streams
Performance Evaluation

(d) Energy Consumption Per Delivered Data Byte
Performance Evaluation

- Different System Loads
  - Use gossip traffic

(b) Aggregate Throughput in MAC
Performance Evaluation

(d) Energy Consumption Per Delivered Data Byte
Conclusions

• Contributions
  – First multi-frequency MAC, specially designed for WSN, where single-transceiver devices are used
  – No RTS/CTS overhead
  – Explore tradeoffs in frequency assignment
  – Design toggle snooping