Dozer
Ultra-Low Power Data Gathering in Sensor Networks

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Environmental Monitoring

- Continuous data gathering
- Unattended operation
- Low data rates
- Battery powered
- Network latency
- Dynamic bandwidth demands

Energy conservation is crucial to prolong network lifetime
Energy-Efficient Protocol Design

- Communication subsystem is the main energy consumer
  - Power down radio as much as possible

<table>
<thead>
<tr>
<th>TinyNode</th>
<th>Power Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>uC sleep, radio off</td>
<td>0.015 mW</td>
</tr>
<tr>
<td>Radio idle, RX, TX</td>
<td>30 – 40 mW</td>
</tr>
</tbody>
</table>

- Issue is tackled at various layers
  - MAC
  - Topology control / clustering
  - Routing

→ Orchestration of the whole network stack to achieve duty cycles of ~1%.

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Dozer System

• Tree based routing towards data sink
  – No energy wastage due to multiple paths
  – Current strategy: SPT

• TDMA based link scheduling
  – Each node has two independent schedules
  – No global time synchronization

• The parent initiates each TDMA round with a beacon
  – Enables integration of disconnected nodes
  – Children tune in to their parent’s schedule
Dozer System

- Parent decides on its children data upload times
  - Each interval is divided into upload slots of equal length
  - Upon connecting each child gets its own slot
  - Data transmissions are always ack’ed

- No traditional MAC layer
  - Transmissions happen at exactly predetermined point
  - Collisions are explicitly accepted
  - Random jitter resolves schedule collisions

Clock drift, queuing, bootstrap, etc.
Evaluation

• Platform
  – TinyNode
    – MSP 430
    – Semtech XE1205
  – TinyOS 1.x

• Testbed
  – 40 Nodes
  – Indoor deployment
  – > 1 month uptime
  – 30 sec beacon interval
  – 2 min data sampling interval
Dozer in Action
Tree Maintenance

1 week of operation

on average 1.2%

Node id

Connection attempts

Packet loss
Energy Consumption

Mean energy consumption of 0.082 mW

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Conclusions & Future Work

• Conclusions
  – Dozer achieves duty cycles in the magnitude of 1‰.
  – Abandoning collision avoidance was the right thing to do.

• Future work
  – Incorporate clock drift compensation.
  – Optimize delivery latency of sampled sensor data.
  – Make use of multiple frequencies to further reduce collisions.
Questions?
Comments?

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