Adaptive Neighbor Discovery for Mobile and Low Power Wireless Sensor Networks

**Motivation**

**Design**

**FixedND**

**AdaptiveND**

**Extensions**

**Implementation**

**Evaluation**

**Simulations**

**Real World**

**Next Steps**

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**Adaptive Neighbor Discovery for Mobile and Low Power Wireless Sensor Networks**

**MSWIM 2012 – Ses.15 : Wireless Sensor and Mesh Networks**

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October 24, 2012
Neighbor Discovery

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Low Power and Lossy AdHoc Wireless Sensor Networks
Neighbor Discovery

- Basic Network Operation.
- Self maintenance, self configuration.
- Base for development of new protocols and algorithms.
How ND fits in the bigger picture

- Notification mechanism to applications.
- Messaging mechanism to send messages to neighbors.
Different Approaches

- Passive Detection,
- Hierarchical,
- Turn Based,
- **Beaconing**
Beaconing

Devices send Beacons every time unit. Reliable but:

- energy demanding
- constant traffic
Starting Point

FixedND

- Constant Beaconing
- Add to neighborhood after $n$ beacons.
- Remove after $m$ missed beacons.

Heavily evaluated in experiments with Clustering, Tracking and Routing during the previous years.
New Neighbor Identification Beacons every 1 sec

Execution with 3 Devices
New Neighbor Identification Beacons every 1 sec

After 1 Second

1 2 3

hello hello hello
After 2 Seconds

New Neighbor Identification Beacons every 1sec

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New Neighbor Identification Beacons every 1 sec

After 3...+ Seconds

1

2

hello:2

hello:1,3

3

hello:1,3

hello:2
Why An Adaptive ND?

We propose to adapt the Beaconing rate based on the Neighborhood changes.

- no changes → relaxed discovery
- any change → increase beaconing & update information
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AdaptiveND

- Beaconing on **variable** Intervals
- Based on the changes of the Neighborhood
- Distributed decisions
- Same Strategy for accepting and rejecting neighbors

Turned to the concept of “polite gossip” to solve our problems.
Stability is the key

Stability is a metric defined as the number of Beacons ($k$) in agreement with the current neighborhood of the node.

- Stable devices relax Beaconing.
- Unstable devices send beacons quickly to regain Stability.
Based on the setup we provide two operation modes:

- **Fix**\(^k\): All Devices use the same Stability Threshold (suitable for **mesh or fixed networks**).
- **Average**\(^k\): Devices calculate Thresholds based on the size of their neighborhood (useful for **Random Deployments**).
Extra parameters used to refine ND

As in most cases simple beacon exchanges are not enough we introduced some extra parameters to refine results:

- LQI and RSSI for incoming beacons.
- Bidirectional link identification.
- Add local information to beacons for neighbor feedback.
Hardware Independent Implementation

Wiselib is an algorithms library for networked embedded devices.

Over **60 WSN Algorithms** for Clustering (LCA and MaxMinD), Routing (DSDV AODV RPL), Cryptography (ZKP) or Localization can be compiled for several platforms such as iSense or Contiki, or the sensor network simulator Shawn.

Available on Github @ http://wiselib.org
Software Independent Beacons

We use cross-implementation Beacons compatible with other implementations (i.e., for Arduino and SunSpot Devices).
Evaluation Setup

- **WSN Simulator Shawn**
  - scalability and performance
  - ✓ Network Density and Size
  - ✓ Controlled Message and Node Failures
    www.itm.uni-luebeck.de/ShawnWiki/

- **WISEBED testbed facilities**
  - → real world implications
  - ✓ Mobility and Low-Power Scenarios
  - ✓ Different locations around the E.U.
  - ✓ Federated Experiments
    http://wisebed.eu
Simulations: Scalability

Up to 90% less beacons exchanged in stable environments.
Significantly increased Beaconing during the Failure Period (2).
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Real World: Testbed Layout
Real World: Wall Mounted Devices
Real World: Mobility Experiments (Setup)

Walk path for the mobile device and positions of fixed devices.
Real World: Mobility Experiments

![Bar Chart]

<table>
<thead>
<tr>
<th></th>
<th>Messages per Minute</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Mobility</td>
<td>2</td>
</tr>
<tr>
<td>Slow Walk</td>
<td>9</td>
</tr>
<tr>
<td>Mobile Node</td>
<td>16</td>
</tr>
<tr>
<td>Slow Walk</td>
<td>9</td>
</tr>
<tr>
<td>Fixed Nodes</td>
<td>16</td>
</tr>
<tr>
<td>Fast Walk</td>
<td>23</td>
</tr>
<tr>
<td>Mobile Node</td>
<td>23</td>
</tr>
<tr>
<td>Fast Walk</td>
<td>9</td>
</tr>
<tr>
<td>Fixed Nodes</td>
<td>9</td>
</tr>
</tbody>
</table>
Real World: Lifetime Experiments

![Network Lifetime Graph]

- **Network Lifetime**
- **FixedND** vs. **AdaptiveND**
- **Lifetime in minutes**

20% Extended Lifetime
Conclusions and Next Steps

AdaptiveND offers:

- Reduced messaging rates by 90%.
- Increased network lifetime by 20%.
- Lower network traffic.

Next Steps

- Evaluate Duty Cycling Strategies. (ongoing)
- Use AdaptiveND together with other Protocols. (ongoing)
- Large Scale Federated Experiments using Wisebed. (planned)
Thank you!

Q&A