TREECAST:
A STATELESS ADDRESSING AND ROUTING ARCHITECTURE FOR SENSOR NETWORKS

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Outline of the Talk

- Introduction
- TreeCast architecture
- Scoped addressing
- Evaluation
- Related work
- Summary
Introduction

- Hardware size and cost has gone down

- A sensor network is a network of sensor nodes deployed in abundant quantities
Motivation

- Sensors should be stateless
- We should take advantage of the unique communication pattern in sensor networks
  - Communication between sink node and sensors
TreeCast Architecture

- Address allocation
- Tree maintenance
- Routing
TreeCast – Address Allocation

- Sink node chooses $b$ such that

\[2^b > \text{Average number of single hop neighbors}\]

- Reserve $b$ bits for each level of address

\[(0|1)^{bk}\]
Address Allocation

Level 0

Level 1

Level 2

Level k
Address Allocation

CHOOSE PARENT

DO ALLOCATION

HEAR ALLOCATION

No Address

Confirmed Address

Wait for child PROBE

Timer expire

Rx CONFIRM

 packets

YES

Prefix Address

Select Parent

Generate Probable Address

Rx packet from Parent

Rx PROBE

Detect conflict

YES

 Tx COMPLAINT

 Tx APPROVE

NO

Tx CONFIRM

COMPLAINT/Timeout

APPROVE

Tx PROBE
TreeCast – Tree Maintenance

- Nodes can lose their parents
  - Node failure
  - Node movement
- New nodes can join
Tree Maintenance

- Node sends parent solicitation request
- All possible parents reply with respective address and value of $b$
- Orphan node randomly chooses from all responding nodes with lowest level
- Initiates DO ALLOCATION
TreeCast – Routing

- Query
- Response
- Peer-to-peer communication
Query Routing

- Sink floods query to all sensors
- Node receives query packet from parent and forwards it to children
Response Routing

Level 0

Level 1

Level 2

Level k
Scoped Addressing

- Assumption of global flooding not always true
- Target particular group of sensors using
  - Address aggregation
  - Query optimization
Address Aggregation

- Set approximation based on query specification
  - Threshold based

![Diagram showing a network with a sink and nodes A, B, C, D, and R.]
## Evaluation

<table>
<thead>
<tr>
<th>Parameter Name</th>
<th>Parameter Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>1000 m x 1000 m</td>
</tr>
<tr>
<td>Number of nodes</td>
<td>200</td>
</tr>
<tr>
<td>Transmission range</td>
<td>125 m</td>
</tr>
<tr>
<td>Node density</td>
<td>~ 10</td>
</tr>
<tr>
<td>Bits per level</td>
<td>8</td>
</tr>
</tbody>
</table>
Sample tree
Address Allocation
Routing under Node Failure
Scoped Addressing

Normalized number of transmitted addresses

- area bounded query
- random distributed query
Scoped Addressing
Related Work

- Data centric routing in sensor networks
  - Directed diffusion, SPIN
  - Our work facilitates such design

- Routing in ad hoc networks
  - Unsuitable for sensor networks
  - Assumes peer-to-peer communication model
Summary

- Novel way to auto-configure sensor networks
  - Creates multiple, intertwined, balanced trees
  - Can selectively use these trees
- Stateless addressing scheme using address aggregation
END
Contribution

• Enabling stateless routing in sensor networks by automatic address assignment to sensor nodes
Orphan Response Routing

- Nodes wait for implicit acknowledgement
- Orphan node sets `ANY_PARENT` flag
- If still no success, then set `LATERAL` flag
Peer-to-Peer Routing

Level 0

Level 1

Level k
Address Aggregation

- Address coalescence
  - OID compression technique from SNMP

```
1.2.3.5.6.7
1.2.3.4.6.7.8
1.2.3.4.5.6.7.8
1.2.3.4.5.6.7.8 * 5;6.7.8 * 4;5,6,7
```
Query Optimization

1.2.2

1.2.3

1.2.3.4.5.6.7.8 * 5;6.7.8 * 4;5,6,7

1.2.3.4

1.2.3.5

1.2.3.4.5.6.7.8 * 5;6.7.8

1.2.3.4.6

1.2.3.5.6.7

1.2.3.4.5.6.7.8

1.2.3.4.6.7.8
Scoped Addressing

The graph shows the packet overhead (in bytes) as a function of the threshold of aggregation. The x-axis represents the threshold of aggregation as a percentage, and the y-axis represents the packet overhead. Two lines are plotted: one for 'flood' and another for 'TCast'. As the threshold increases, the packet overhead decreases for both methods.
Scoped Addressing
Reinforcement Learning

- Sink floods query for very first time
- After response, sink node has idea of relevant sensors
- Use “query optimization” to target relevant queries