**Distributed Index** for **Multi-dimensional data in sensor networks**

Xin Li, Young Jin Kim, Ramesh Govindan, Wei Hong
University of Southern California, Intel Research Berkeley

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### Motivation

- Provides support for multi-dimensional range queries in sensor networks when in network storage is applied.
  - e.g. List all events whose temperature lies between 70 and 80 and whose light levels are between 10 and 15.
- Can be used for searching and correlating events of interests with multiple attributes.

### Approach

- Partition the sensor field into zones (bins).
- Data locality preserving hashing from m-d space to geographic locations.

### Components

- A recursive and distributed sensor field partition scheme that
  - Divides network into zones along attribute dimensions.
  - Organizes zones into a virtual binary tree.
  - Encodes zones based on their locations on the tree.
- A locality preserving hashing scheme that maps data and queries to zones.
- A query split scheme that divides a large range query into smaller queries based on the local tree view.
- A geographic routing like GPSR.

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### Robustness

- Data Robustness
  - Local Replication
    - Back-up node = the new owner of the zone when the current node failed.
    - Good for sporadic failures
  - Mirror Replication
    - Resilient to concurrently failures of geographically contiguous nodes.
    - Doubling both insertion and query costs.
- Query Robustness
  - Resilient to packet loss
  - Selectively reissue part of a query to cover silent zones

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### Analysis & Simulation

<table>
<thead>
<tr>
<th>Query size distribution</th>
<th>Average query cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniform</td>
<td>$O(\sqrt{N})$</td>
</tr>
<tr>
<td>Bounded uniform</td>
<td>$O(h)$</td>
</tr>
<tr>
<td>Algebraic</td>
<td>$O(\sqrt{N})$</td>
</tr>
<tr>
<td>Exponential</td>
<td>$O(\sqrt{N^d})$</td>
</tr>
</tbody>
</table>

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### DIM on Motes

- Zone
- Query
- Insertion
- DIM Dispatcher
- GPSR
- Tuple Storage
- TinyDB Schema
- LLC
- Flash

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**DIM Overview**

**Building Zones**
- Encode events
- Compute geographic destination
- Hand to GPSR
- Intermediate nodes can refine destination

**Data Insertion**
- Encode events
- Compute geographic destination
- Hand to GPSR
- Intermediate nodes can refine destination

**Query**
- Split a large query into smaller subqueries.
- Encode each subquery.
- Process subqueries separately, resolving locally or forwarding to other nodes based on their codes.

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**Query Robustness**

- e.g. List all events whose temperature lies between 70 and 80 and whose light levels are between 10 and 15.