Title
SYS5: Sympathy for the Sensor Network Debugger

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**Sympathy for the Sensor Network Debugger**

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**Problem: Debugging Sensor Networks is Difficult**

**Challenges**
- WSN debugging is challenging
  - Minimal resources, limited visibility, & unpredictable environmental interactions
- Sympathy is deployed at James Reserve and in the lab, and has detected many hard to track down failures; e.g.
  - Detected a routing loop caused by bug in routing layer
  - Detected congestion caused by dense neighborhoods

**Contributions**
- Identified **metrics** and **analyses** that help programmers detect failures and correlate events into the **root causes of bugs**
- **Insight:** Insufficient data delivery => Failure
  - For a large class of applications (defined below)
  - Small step towards autonomous robustness
  - What are the limits to system self repair?
  - How can we **generalize** across conditions, deployments, and systems?

**Proposed Solution: Sympathy collects metrics to identify and localize failures**

**How It Works**
1) Nodes periodically send selected metrics to a sink
2) Sink identifies failures in data throughput, and
3) Sink analyzes the metrics to determine the cause for data interruption

**Identifying Failures**
- Initial model: Applications that collect node data at a sink
  - “Regular” data exchange required; interruptions are unexpected
  - Generalize for future work
- Insufficient data delivery => Failure
  - “Insufficient” defined by components
  - Detect by continuously monitoring collected metrics and data

**Localizing Failures**
- Determining why data is missing
  - Physically narrow down cause
  - E.g. Where is the data lost

**Statistics Collected**

<table>
<thead>
<tr>
<th>Node Statistics</th>
<th>Component Statistics (tx for each component on a node)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routing Table</td>
<td>(Sink, next hop, quality) tuples.</td>
</tr>
<tr>
<td>Neighbor List</td>
<td>Neighbors and associated ingress/ egress</td>
</tr>
<tr>
<td>Time awake</td>
<td>Time node is awake</td>
</tr>
<tr>
<td>#Statistics tx</td>
<td>Number of statistics packets transmitted to the sink</td>
</tr>
<tr>
<td>#Pkts Routed</td>
<td>Number of packets routed by the node</td>
</tr>
<tr>
<td>#Pkts comp rx</td>
<td>Number packets component has received</td>
</tr>
<tr>
<td>#Pkts comp tx</td>
<td>Number packets component transmitted</td>
</tr>
<tr>
<td>Last timestamp</td>
<td>Timestamp of last data sample stored by comp</td>
</tr>
</tbody>
</table>

**Results**

- Time Detect Failure, Varying Traffic
- Number of Spurious Failures, No Traffic
- Sympathy Added Overhead, Varying Statistics Period and Traffic