Algorithms for energy efficient data extraction from wireless sensor networks for environmental monitoring applications

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Overview

• Motivating application
  – Great Barrier Reef (GBR)
  – Problems with current setup
  – Our solution: Wireless sensor networks (WSNs)

• Algorithms
  – Taking advantage of:
    • Spatial correlations
    • Temporal correlation

• Future work
WSN deployment at the Great Barrier Reef
WSN deployment at the Great Barrier Reef

- Australian Institute of Marine Science (AIMS)
  - Temperature patterns
  - Effects of global warming on the GBR
  - Fisheries
  - Monitoring pollution

Coral bleaching

Trawling

Monitoring pollution

Mountains

Farm lands

Pollutants from rivers

Great Barrier Reef

Mountains

Acheron Island
WSN deployment at the Great Barrier Reef

• Current setup at Davies Reef
WSN deployment at the Great Barrier Reef

- Current setup at Davies Reef
  - Two points of data collection
  - Data is collected on a half hourly basis at the weather station and is stored on a logger
  - Data is retrieved manually periodically
WSN deployment at the Great Barrier Reef

- Problems with current setup
  - Unable to perform
    - Fine-grained monitoring
    - Real-time monitoring
  - Labour intensive
    - Data needs to be retrieved manually
  - Low resolution
WSN deployment at the Great Barrier Reef

• Proposed WSN deployment at AIMS
  – Sensor network on GBR

Antenna → Buoy → Water-tight canister containing Ambient Sensor Node

Sensor string

Temperature
Or
Light Sensor
Data is transmitted from the sensors to the embedded PC at the weather station.
Microwave data transmission at 10.4GHz using humidity ducts above ocean as a wave guide
Challenges of WSN deployment

- Limited energy supply
  - Battery-operated
- Limited transmission capability
  - Devices sleep most of the time
- Large numbers + Harsh environment
  - Impossible for people to manage manually
Challenges of WSN deployment

- **Raw data collection**
  - High energy-consumption
    - Large amount of data needs to be transmitted
    - Sensor sampling
  - Bottlenecks
    - Especially close to the sink node
  - Poor data quality
    - Limited bandwidth can lead to dropped packets
Our approach

• Initial deployment

Nelly Bay, Great Barrier Reef
Our approach

- Initial deployment
Our approach

- Algorithms to take advantage of
  - Spatial correlations
    - Between sensor readings of adjacent sensor nodes
  - Temporal correlation
    - Between consecutive sensor readings of a single sensor
Spatial correlation

DOSA: Distributed and Self-Organizing Scheduling Algorithm for Data Aggregation

Communication Tree
- Correlating Node
- Non-Correlating Node
- Sensor Readings
- Correlation Information

Gateway Node
Computes readings using correlation info

Works out correlation info:

<table>
<thead>
<tr>
<th>Node</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1</td>
<td>+2.0°C</td>
</tr>
<tr>
<td>N2</td>
<td>+1.3°C</td>
</tr>
<tr>
<td>N3</td>
<td>-2.7°C</td>
</tr>
<tr>
<td>N4</td>
<td>+3.3°C</td>
</tr>
</tbody>
</table>
Spatial correlation - Results

DOSA: Distributed and Self-Organizing Scheduling Algorithm for Data Aggregation

- Improvement of network lifetime and data quality

![Network lifetime (days)](image1)

![Packet loss (%)](image2)
Temporal correlation

- Nodes predict readings locally using *time-series forecasting*
  - Constant trend → Predictable → Reduce sampling & transmission
  - Changing trend → Unpredictable → Increase sampling & transmission
Temporal correlation - Results

- Overall: Sensor sampling (EXCELL salinity sensor) + Transceiver operation (RFM TR1001)
- > 90% data within user-specified threshold
Future work

- Communication protocols
  - Disturbance due to waves
- Combining algorithms
  - Take advantage of spatio-temporal correlations at the same time
Thank you!