Scoping for Multipurpose Wireless Sensor Networks

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Outline

1 Motivation
   - State of the Art
   - Demand for Multipurpose WSNs
   - Challenges

2 Our Approach
   - Architecture
   - Scope Specification and Membership
   - Routing

3 Summary
Wireless Sensor Networks: Common Assumptions

Hardware:
- 1000s of inexpensive sensor nodes
- Sensors: temperature, humidity, …
- nodes have short range radio interfaces

Goal:
- nodes form multi-hop ad-hoc network
- sink node(s) collects selected sensor data
- resilience to node and link failures

Challenges:
- nodes have limited capabilities (µC, few kB of RAM and ROM)
- battery power is scarce
- ad-hoc and distributed
Aberrations from Common Assumptions

- Battery life-time only one aspect of total cost
- Structured environment to be mapped to sensor network
Current WSN Software Development and Architecture

Special purpose:
- Single task for all sensor nodes
- Optimized custom solutions based on low level hardware or software interfaces
- Tight integration of query processing, data collection, aggregation, routing, medium access
- Reprogramming often requires physical access
Towards Multipurpose Sensor Networks

What if...
- there are multiple applications within an environment?
- wireless sensor networks overlap?
- multiple parties are involved?
Towards Multipurpose Sensor Networks

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A shared infrastructure will…

- reduce total cost (hardware, maintenance, management)
- reduce overhead for routing etc.
- use radio channels more efficiently
- increase coverage or density with same number of nodes
Challenges of Multipurpose WSNs

Node level:
- Multitasking
- Memory Management
- Runtime deployment of tasks
- Life-cycle management

Already some projects:
- Query engines
- Maté Virtual Machine (Berkeley)
- SOS Operating System (UCLA)

Network level:
- Assigning tasks to relevant node sets only
- Maintaining node sets and connectivity
- Different requirements
- Access control

Some related work:
- Scoping in event based systems
- Geographic routing in WSNs
- Regions based WSN algorithms
- Many open problems!
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**Many open problems!**
Our Main Focus: Scoping in WSNs

How to...

- specify sets of scope members?
- support different types of membership conditions?
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- achieve access control?
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How to...

- specify sets of scope members?
- support different types of membership conditions?
- discover relevant nodes?
- handle dynamic selection conditions?
- maintain routing trees to scope members?
- achieve access control?
- implement different communication semantics?
Architecture Overview

- Application Layer
- Scope State
- Routing
- Hardware Abstraction
## Architecture Overview

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<th>Application Layer</th>
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<th>VM, Query engine, etc.</th>
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**Architecture Overview**

- **Application Layer**
  - Lifecycle

- **Scope State**
  - Scope-membership decision

- **Routing**
  - Discovering potential scope members
  - Maintaining path to members

- **Hardware Abstraction**

**Tasks**
- Task 1
- Task 2
- ... Task N

**VM, Query engine, etc.**
Each node has static or dynamic properties

- Static: available sensor types, meta-data,…
- Dynamic: location, distance, number of neighbors,…
- Scenario-specific properties as modules

Scope membership condition

- Boolean expression over node properties
- Represented in postfix notation as byte-code
- Evaluated locally
Architecture Overview

Application Layer
- Lifecycle
- VM, Query engine, etc.
- Task 1, ..., Task N

Scope State
- Current Scope States
- Evaluator
- Dynamic Cond.
- Properties
- Modules

Routing

Hardware Abstraction

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Common routing tree or mesh connects all nodes (global base scope)
- Scopes can be nested (efficiency, access control)
- Routing tables for scopes at forwarding nodes
- Narrow interface to scoping layer (modularity)
Architecture Overview

- **Application Layer**
  - Lifecycle
  - VM, Query engine, etc.
    - Task 1
    - …
    - Task N

- **Scope State**
  - Current Scope States
  - Evaluator
  - Dynamic Cond.
  - Properties
    - Modules

- **Routing**
  - Receiving, Forwarding, Sending
  - Route selection
    - Modules

- **Hardware Abstraction**
Summary

Commercial applications raise new challenges for WSN

- Cost effective
- Modular and flexible
- Shared infrastructure
- Structured environment

Scoping as main building block for multipurpose WSN

- Issues: Specification, Deployment, Maintenance
- Modular architecture

Enhancements

- Access control
- Scope specific communication semantics
Thank you!

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