Energy-Efficient Management of Heterogeneous Wireless Sensor Networks using Multicast Communication

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Agenda

> Introduction
  — Management Scenario
  — Overall Picture of the System

> Management Functionality
  — MARWIS

> Multicast Communication
  — SNOMC

> Heterogeneous Networks

> Conclusion

> Discussion

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Management Scenario

Energy-Efficient Management of Wireless Sensor Networks using Overlay Multicast

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Overall Picture of the System

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Management Functionality

> Goals
  — Monitoring, Configuration, Code Update
  — Efficient and Energy-Efficient

> Management Architecture for Wireless Sensor Networks (MARWIS)

> Components
  — Management station
  — WSN Manager on mesh nodes
  — SN Agent on sensor nodes
Management Functionality: User Interface (1)
Management Functionality: User Interface (2)

MARWIS
Management Architecture for Wireless Sensor Networks

Sensor Node sn01:
- Node Info:
  - IP: 10.1.10.101
  - Gateway: 10.1.10.101
  - Platform: TelosB
  - Operating System: Contiki
  - Mesh Node: marwissn01
  - Microcontroller: MSP430
  - Radio Transceiver: CC2420
  - Current Voltage (V): 2.953
  - LED Red: on
  - LED Green: on
  - LED Blue: off

- LEDs:
  - Red
  - Green
  - Blue

-Sensors:
  - Photosynth. Active Radiation (Lux)
  - Total Solar Radiation (Lux)
  - Relative Humidity (%)
  - Temperature (°C)

Sensor Node sn02:
- Node Info:
  - IP: 10.1.10.102
  - Gateway: 10.1.10.102
  - Platform: TelosB
  - Operating System: Contiki
  - Mesh Node: marwissn01
  - Microcontroller: MSP430
  - Radio Transceiver: CC2420
  - Current Voltage (V): 2.529
  - Battery max (mAh): 3300
  - Battery curr (mAh): 2399
  - LED Red: on
  - LED Green: on
  - LED Blue: off

-Sensors:
  - Photosynth. Active Radiation (Lux)
  - Total Solar Radiation (Lux)
  - Relative Humidity (%)
  - Temperature (°C)
Management Functionality: Protocols

> Management Protocols
  — Monitoring Protocol
  — Configuration Protocol
  — Code Update Protocol

> Example: Code Update
  — Transmitting the application to the selected sensor nodes
  — Acknowledge about the success of the update
Multicast Communication

> Goals

— Reliability:
  - Supporting end-to-end reliability
  - Distributing the responsibility for reliability on different protocol layers and avoiding end-to-end retransmissions

— Energy-efficiency
  - To reduce number of transmissions using multicast communication and using broadcast communication on link layer
  - To avoid end-to-end retransmissions using caching mechanisms

— Supporting heterogeneous networks
  - IP-based communication
  - Overlay Multicast
Multicast Communication: SNOMC (1)

- Sensor Node Overlay Multicast (SNOMC) protocol
- Goal: Avoiding redundant unicast connections
- Role of nodes
- Multicast schemes
  - Receiver-driven vs Source-driven
- Overlay Multicast
  - UDP as transport protocol
- Reliability
  - End-to-end reliability using NACKs and closing positive ACKs
  - Caching:
    - Only on source node
    - On branching nodes
    - On every intermediate node
Multicast Communication: SNOMC (2)

> Implemented in OMNeT++
  — Source-driven and receiver-driven
  — 3 caching mechanisms
  — BEAM as MAC protocol with H2HR

> Implemented in Contiki
  — Source-driven
  — 3 caching mechanisms
  — NullMAC as MAC protocol
Multicast Communication: Evaluation (1)

- Goal: Comparing SNOMC with different transport protocols
  - Flooding
  - Multipoint Relaying (MPR)
  - Directed Diffusion
  - Unicast (TCP/UDP)

- ... in both multicast schemes (source-, receiver-driven), using 3 caching mechanisms, and ...

- ... in combination with different MAC protocols
  - NullMAC
  - BEAM
  - X-MAC / ContikiMAC
Multicast Communication: Evaluation (2)

Problem: Comparability between the simulated results and the real-world results

- Different protocol stacks
- Different scenarios
- Operational delays in Contiki not taken into account in OMNeT++
- Missing implementations of “standard” protocols in Contiki (Directed Diffusion, MPR)
Multicast Communication: Evaluation (3)

> Simulated World vs Real-World
> Simulation:
  — 9 nodes, 3 receivers, max 7 hops, BEAM/H2HR
> Real-World:
  — 6 nodes, 3 receivers, max 4 hops, NullMAC
Multicast Communication: Broadcast

> Optimize multicast using broadcast on link layer
  — avoid redundant unicast transmissions on link layer

> Challenge: Reliable Link Layer Broadcast
  — Explicit vs implicit acknowledgement
Multicast Communication: IP Multicast

> IP Multicast
  — No implementation in Contiki

> Scalable Adaptive Multicast (SAM)
  — Research Group of the Internet Research Task Force (IRTF)
  — Draft, no implementation
Heterogeneous Networks

> Goal: Supporting heterogeneous wireless sensor networks
  — TelosB / TmoteSKY
  — MSB
  — BTnodes

> Using wireless mesh nodes

> Management functionality on all types of nodes

> IP-based communication
Heterogeneous Networks: SNOMC

> Supporting Overlay Multicast in heterogeneous WSNs
  — SNOMC in Contiki
  — SNOMC over Wireless Mesh Networks

> Same protocol for different networks
Conclusion

> Management Scenario
> Overall Picture of the System

> MARWIS

> Multicast Communication
   — SNOMC
   — Evaluation Problems
   — Broadcast
   — IP Multicast

> Heterogeneous Networks

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Discussion