Opportunistic Energy Trading between Co-located Energy-Harvesting Wireless Sensor Networks

Teng Jiang, Geoff V. Merrett, Nick R. Harris
Electronic and Software System group
ENSsys 2013, Nov. 2013
Email: tj2g11@ecs.soton.ac.uk
Outline

• Power Management Technologies in EH-WSN
• Opportunistic Energy Trading
• Case Study: energy transfer process
• Evaluation and Results
• Conclusions
Outline

• Power Management Technologies in EH-WSN
• Opportunistic Energy Trading
• Case Study: energy transfer process
• Evaluation and Results
• Conclusions
Power management in EH-WSN

- Adaptive energy management
  - Uncontrolled sources (e.g. Solar, Wind)

Power management in EH-WSN

- Classification
  - Deal with **Temporal variance**
  - Adjust nodal duty-cycle, sampling rate etc.

---

Power management in EH-WSN

• Classification
  
  – Deal with Spatial variance

• Energy-aware routing, resource reallocation etc.
• Spatial variation that can be tolerated is limited by the bounds of the network

Collaborating networks

Network A

Network B

Cross-boundary injection

Data flows with different directions

Sensor node

Sink node

Associated pair of boundary nodes

Network Boundary

Dataflow

Sensor node

Sink node

Outline

• Power Management Technologies in EH-WSN
• Opportunistic Energy Trading
• Case Study: energy transfer process
• Evaluation and Results
• Conclusions
Opportunistic Energy Trading

- Manage power across the boundary
Opportunistic Energy Trading

- Manage power across the boundary
Opportunistic Energy Trading

- Manage power across the boundary
Opportunistic Energy Trading

• Manage power across the boundary
Opportunistic Energy Trading

- Manage power across the boundary
Opportunistic Energy Trading

• How?
  – Energy is logically transferred through the transfer of energy-hungry services

• Is this possible?
Direct Interconnection

- Propose OI-MAC
  - Discover the presence of neighbouring networks
  - Transmit packets across the boundary
  - Still maintain network independence

Outline

• Power Management Technologies in EH-WSN
• Opportunistic Energy Trading
• Case Study: energy transfer process
• Evaluation and Results
• Conclusions
Case study

Discovery

Battery monitoring to check excess energy

Yes

Inform B to start cooperation

No

Inform B to stop cooperation
Outline

- Power Management Technologies in EH-WSN
- Opportunistic Energy Trading
- Case Study: energy transfer process
  - Evaluation and Results
- Conclusions
Evaluation

• The scenario is simulated using OMNeT++
  – The nodes in network A are modelled to be Memsic eKo mote
  – The nodes in network B are modelled to be MICAz mote
  – Real radiation power are used and each photovoltaic is assumed to be 10% efficient
Results: packet delay

Network A

Delay (s)

Without Energy Trading  With Energy Trading

3%
Results: packet delay

Network B

![Bar chart showing delay for Network B with and without energy trading across different hop counts.](chart.png)
Results: battery energy

Network A

Residual Battery Energy (%) vs Time (days)

- Average with Energy $T_{\text{avg}}$
- Minimum with Energy $T_{\text{min}}$
- Maximum with Energy $T_{\text{max}}$
- Average without Energy
- Minimum without Energy
- Maximum without Energy
Results: battery energy

Network B

Residual Battery Energy (%) vs. Time (days)

- Average with Energy Trading
- Minimum with Energy Trading
- Maximum with Energy Trading
- Average without Energy Trading
- Minimum without Energy Trading
- Maximum without Energy Trading
Conclusions

• Opportunistic Energy Trading is proposed
  – Enrich the power management strategies
• Demonstrate the possibility of cross-boundary energy sharing
• Results show the potential benefits as well as side-effects
• Future work
  – Consider networks which share only a limited boundary;
  – Trading process: advertising and pricing of resources.