Achieving Energy–Efficiency in Large and Sparse Wireless Sensor Networks
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Introduction & Motivation

• **Fact 1:** Lack of real-world, long-term, large, and sparse Wireless Sensor Networks (WSNs) [1]
• **Fact 2:** Large WSNs in outdoors have a significant high total cost of ownership (TCO)
• **Traditional approaches in WSNs:**
  - Heavily rely on energy harvesting techniques [1]
  - Solve the high physical coverage area challenge by means of:
    - high #nodes (intensive collaboration)
    - high #infrastructure nodes (~1 per 8 sensor nodes) [1]
• **Our goals** (assumption: low duty-cycle environmental monitoring application):
  - 1 node per ~5,000 m² (54,000 ft²) with low-power transceiver
  - Use 1 infrastructure node per ~30 sensor nodes
  - Achieve overall network overhead < 1%
• **Our strategy:**
  - Design an overlay solution (runs on top of existing hardware/software)
  - Trade network performance for energy-efficiency
  - Homogeneous energy consumption among nodes

Initial Vision

• **Energy efficiency can be significantly enhanced:**
  - **Application:** low duty-cycle
  - **Hardware:** adopt hibernation and design for non-rechargeable batteries
  - **Network:** overhead < 1%
• **Our strategy:**
  - Design an overlay solution (runs on top of existing hardware/software)
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Ultra–Low Power Management Techniques [2]

• **Hibernation technique:** use of electronic switches to power on/off the devices (non-trivial technique)
• **Power-Matching (PM) technique:**
  - only very small currents are supplied by the battery (use of supercapacitors)
  - Without this technique, the lifetime of non-rechargeable batteries in a WSN node is only ~10 to 30% of the expected

BETS: a novel cross-layer protocol for low duty-cycle WSNs [3]

• **2-Tier network:** asynchronous and segmented solution
  - Higher scalability
  - Higher latency
  - Mobile nodes not supported
• **Hybrid and open:** any wireless point-to-point technology
• **New cross-layer protocol (BETS):** application-level overlay
  - Network overhead smaller than 0.5% no matter the network size
  - Impress energy performance due to hibernation and PM techniques

Conclusions & Future Work

• So far, 98 sensor nodes (from a total of +170) have been deployed at the Sacramento (CA) area and Canton (OK): among the largest WSNs so far deployed (in terms or coverage area). The first experiments started on Nov 2011.
• The majority of the nodes already achieved the double lifetime compared with current state-of-the-art WSN solutions.
• The solution imposes a significant time gap between the messages of the nodes (~4s). Nonetheless, the overall message loss is smaller than 5% under very critical deployment scenarios (distances and topography).
• We plan to adapt the solution to Wireless Underground Communication networks [4].

References


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