Communications/networking and energy issues in WSN

Michele Zorzi, zorzi@ing.unife.it
CNIT & University of Padova

Introduction

- Great interest worldwide on fundamental research questions related to networking protocols and communications
- Many open issues
- Need for radically new approaches
- Lack of mature technology and/or established protocol solutions
- Exciting research field with room for basic contributions

Main goals

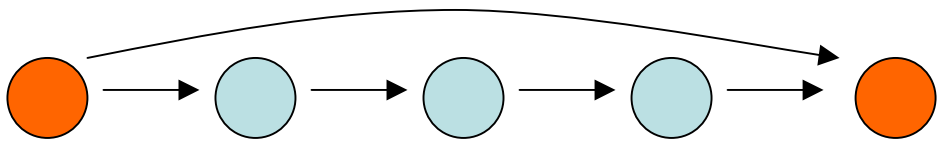
- Develop new ideas and concepts at the networking/protocol level
  - New schemes and paradigms
  - Taking into account energy constraints
- Propose protocol stacks for energy-efficient sensor networking
  - In particular, explore cross-layer solutions
- Provide understanding to guide implementation of actual systems

Coding tradeoffs for multihop

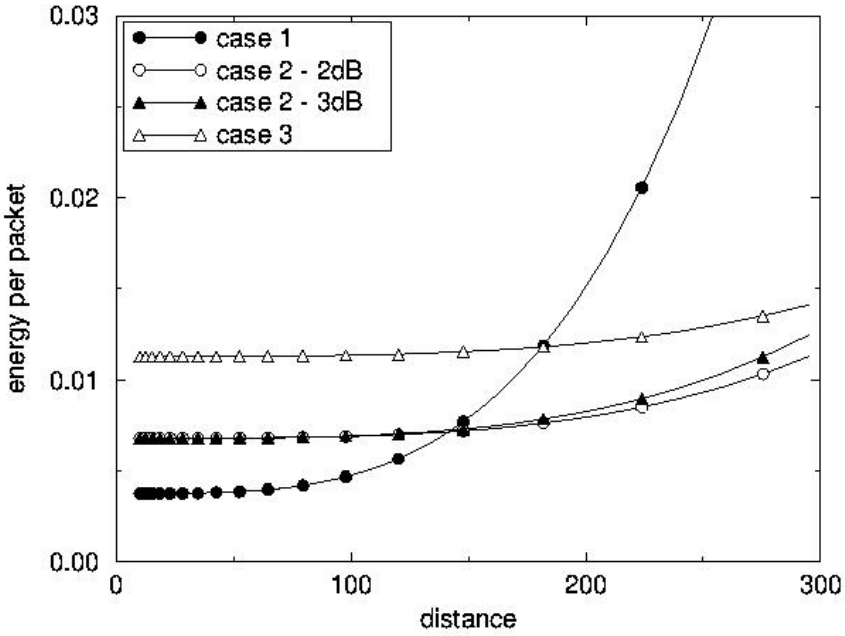
- We address issues at the error control layer
- Problem: deliver reliably a packet to its final destination
  - No aggregation, multi hop operation
- Some considerations in recent literature:
  - Multihop not necessarily good
  - Even coding not necessarily good
- Need to “rethink” common wisdom in communications theory
- Approach:
  - We assume coding is used
  - We compare various multihop solutions

Considered scenarios

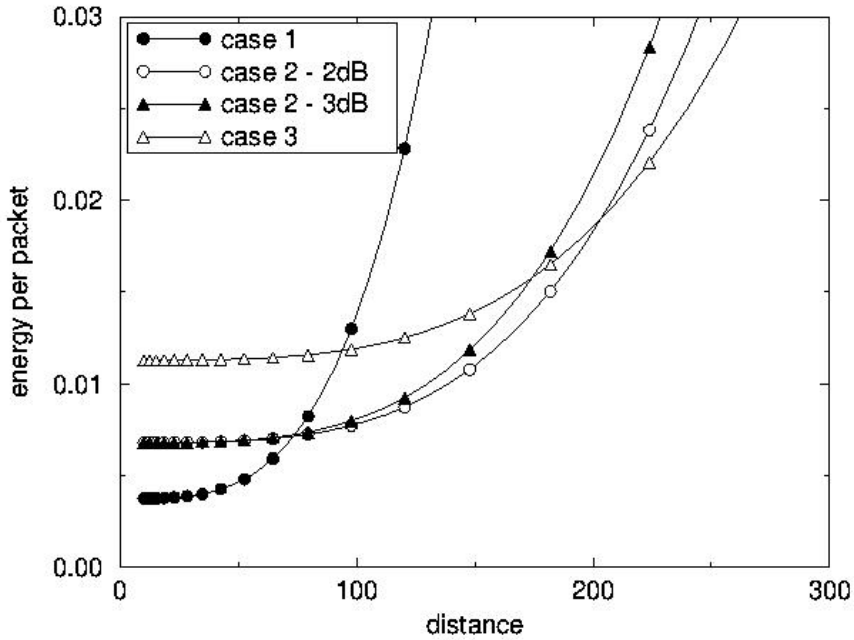
- Preliminary evaluation to understand tradeoffs
- Consider case in which decoding energy is significant
- Three scenarios:
  - Direct transmission from source to destination
  - Multihop transmission with end-to-end FEC
  - Multihop transmission with hop-by-hop FEC



Coding performance – convol. codes



3 hops, Prec = -110dBW



3 hops, Prec = -100dBW

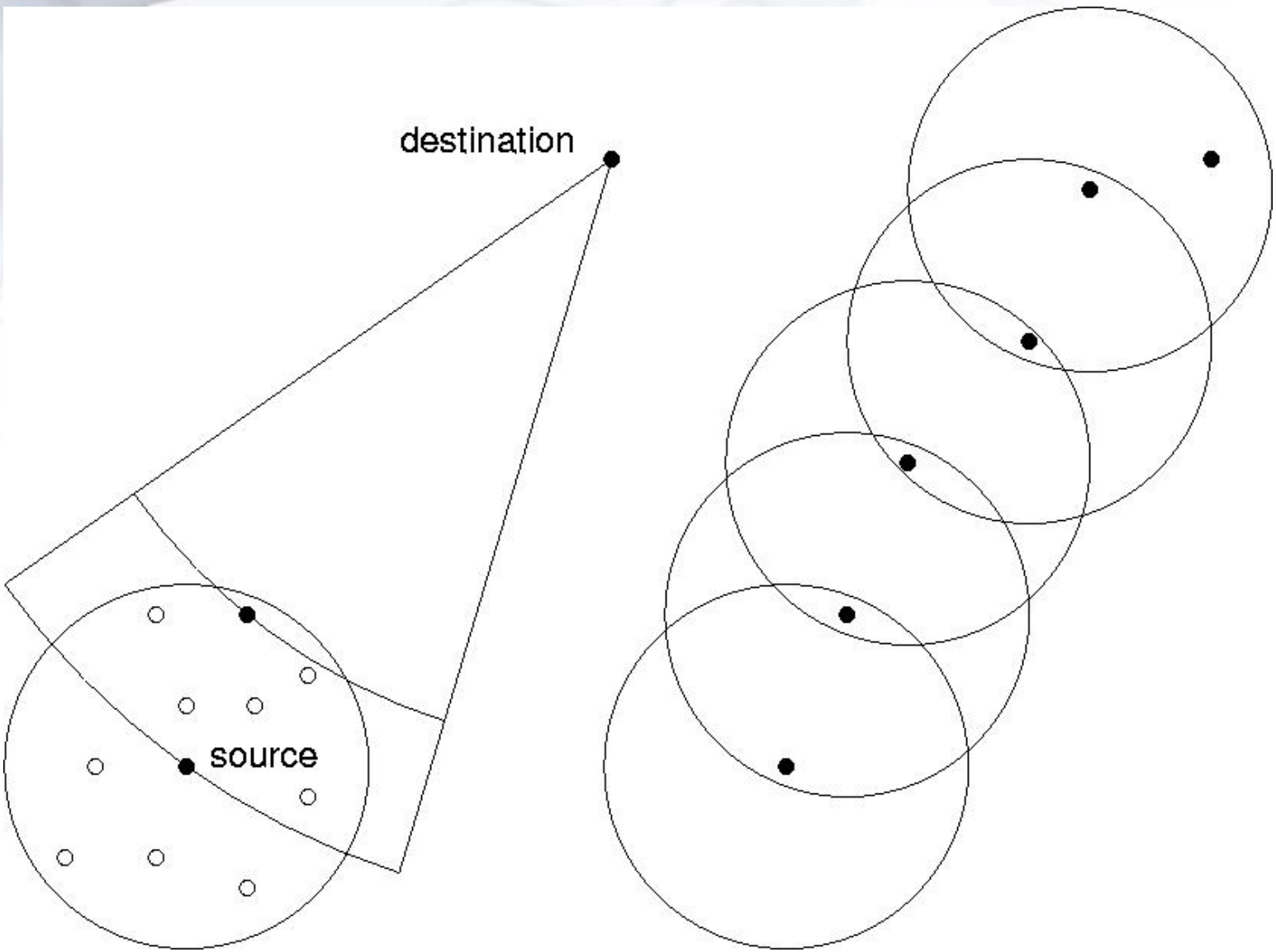
MAC/routing integrated solutions

- Two solutions have been investigated in depth:
  - TDMA-based
  - Contention-based
- Based on a cross-layer approach
- Energy-efficiency a primary concern
- Looking for better options for data transfer across sensor networks
  - Which one to choose will depend on the specific requirements/constraints/goals

Issues in contention-based MAC

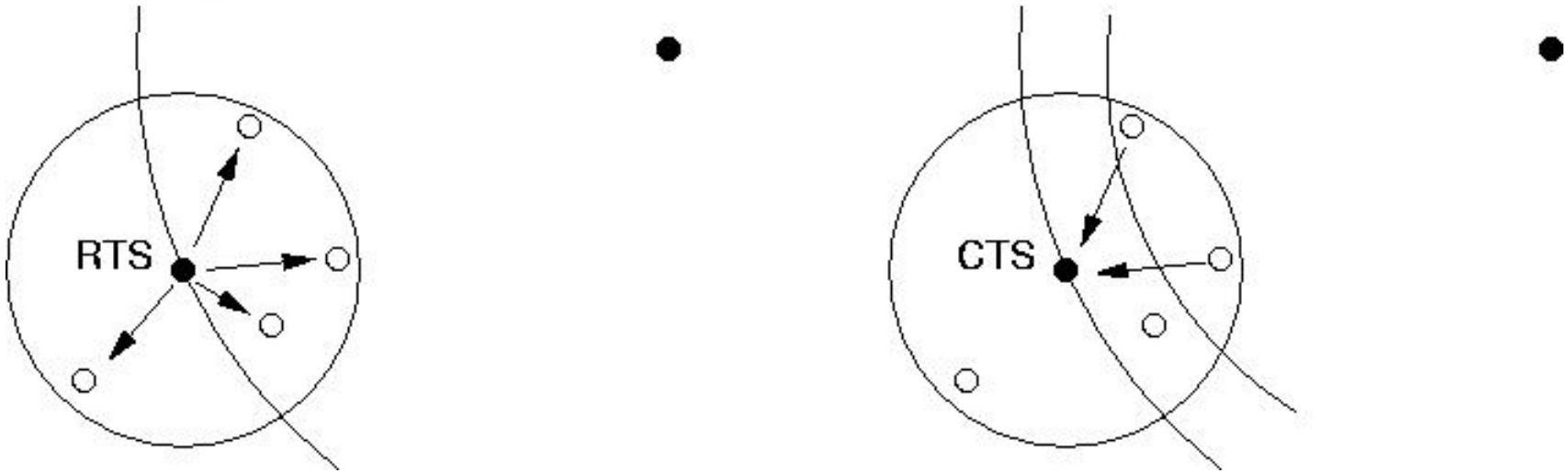
- Main problem to be solved: how to make a contention-based scheme work in the presence of sleep modes
  - Flat solution
  - Busy tones for hidden terminals
  - Random receiver contention for forwarding
- An RTS-CTS protocol has been specified in detail
- Tightly integrated with the routing layer (no clear separation really)
- Extensive performance evaluations

basic idea

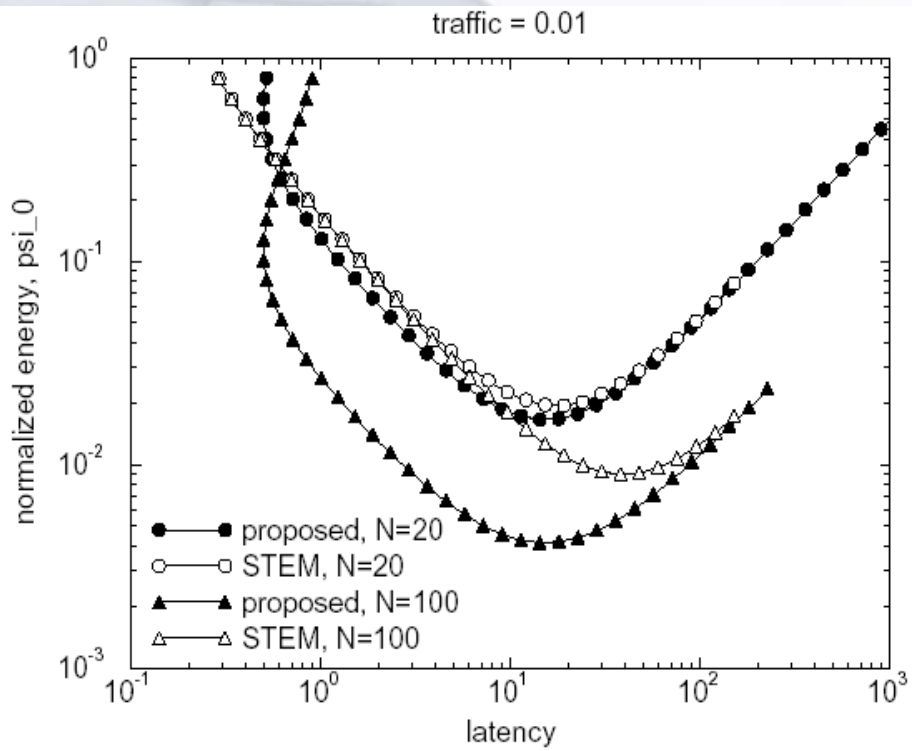


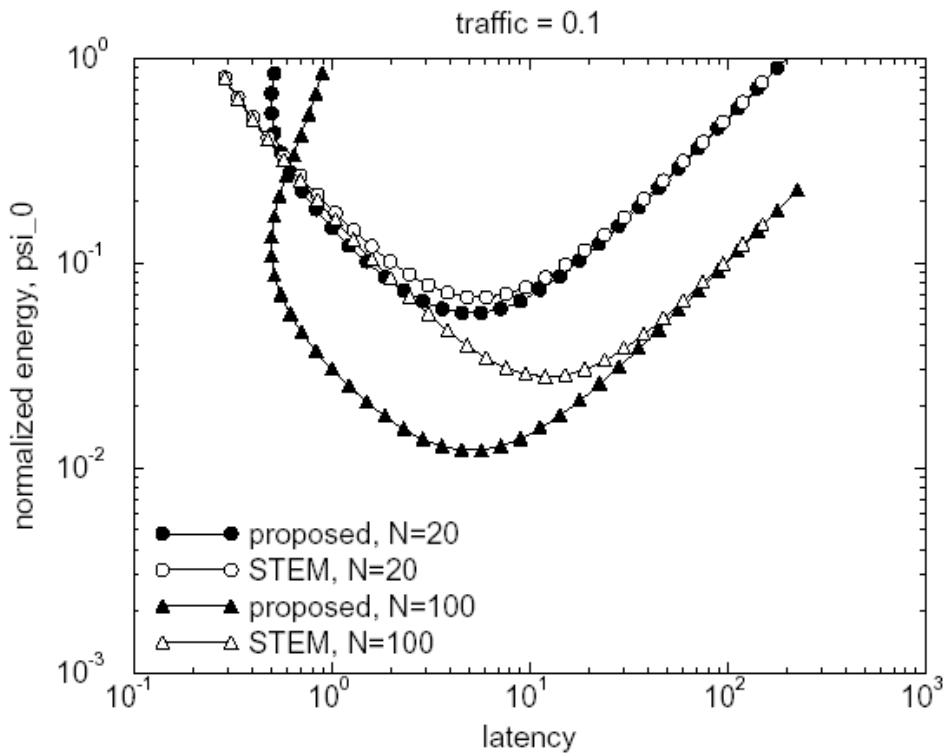
Example of protocol operation

- RTS invites all awake neighbors to become a relay
- Nodes in best position should win



Example results





Tradeoff energy-latency: favorable behavior compared to competing schemes

Topology and clustering

- Flat vs. hierarchical
  - Simulation work has shown that hierarchical cluster based solutions are advantageous
    - reduced overhead + possibility of effective data aggregation
    - Comparisons showed considerable performance improvements
- When to use clustering?
  - It can be combined with many routing protocols
- Topology control issues (how many neighbors?)