TOWARDS INTEGRATED AND SELF-CONFIGURING ROUTING AND INTEREST DISSEMINATION STRATEGIES FOR WIRELESS SENSOR NETWORKS

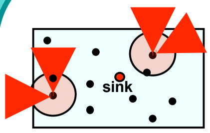
Michele Mastrogiovanni
University of Rome "La Sapienza"
mastrogiovanni@di.uniroma1.it

Chiara Petrioli
University of Rome "La Sapienza"
petrioli@di.uniroma1.it

Michele Rossi
DEI, University of Padova
rossi@dei.unipd.it

Michele Zorzi
DEI, University of Padova
zorzi@dei.unipd.it

An integrated approach



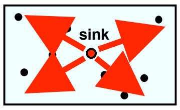
Density estimation: *maximum likelihood*

- Nodes follow sleeping cycles (asynchronous) → duty cycle d
- Neighbor estimation works in rounds
- At each estimation round:
  1. the "inquirer" counts the number of active nodes within range k_i
  2. the "inquirer" *updates a proper likelihood function*:

$$L(n,k_1,k_2,\ldots,k_r,d)=\prod_{i=1}^{r}\binom{n-S(i)}{k_i}d^{k_i}(1-d)^{n-S(i)-k_i}$$

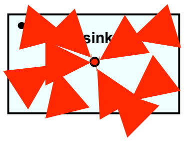
$$n_{MLE}=\arg\max_n L(n,k_1,k_2,\ldots,k_r,d)$$

A close form solution exists!



Interest dissemination: *Fireworks*

- Very simple algorithm with nice properties → *all nodes are reached w.h.p.*
- Whenever a node RX a broadcast (*interest*) it tosses a coin and:
  1. With probability p it re-broadcast the message to all its neighbors
  2. With probability (1-p) it re-broadcast the message to c neighbors
- *Density estimation is executed in parallel*

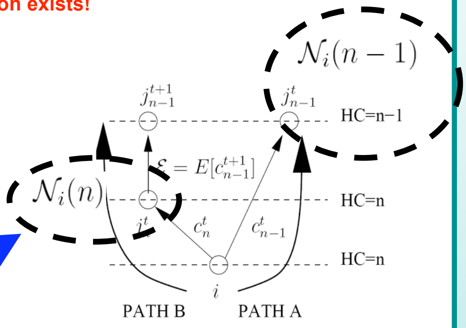


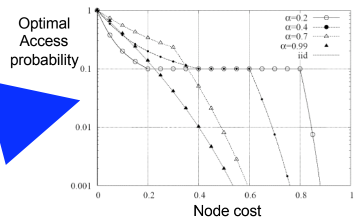
Convergecasting: *SARA MAC/routing protocol*

- Packets are routed to the sink through hop count (HC) coordinates
- Costs are associated with each node/link
- *Routing is modeled as an optimal stopping problem:*

$$V(X_t)=\min_{a(t)\in\mathcal{A}_t}\left[C(X_t,a(t))+\int_{\mathcal{D}_X}V(X_{t+1})\,dF(X_{t+1})\right]$$

- A proper MAC is coupled with HC routing:
  1. CSMA-like → asynchronous
  2. Promote low cost relays → *cost-dependent probabilistic access*
  3. *Access is optimized (delay) by exploiting local density estimates*





EXAMPLE RESULTS (theory & NS2)

Interest Dissemination

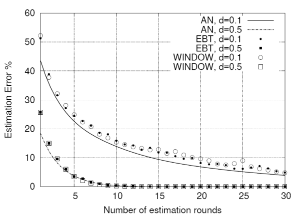
Simulation scenario:
-150 to 300 nodes, uniformly scattered in a square of size 200 m
- Sink placed at the center of the simulation area. Channel bit-rate: 38400 bps
- All nodes have a transmission range of 30 m. c=4 (*Fireworks*). Duty cycle 0.1
- **Sparse networks** (n=150) → *97% of the nodes RX the interest packet*
- **Densely populated** (n>200) → *100% of the nodes RX the interest packet*

Density Estimation

Simulation scenario:
- 20 nodes/coverage
- duty cycles: d=0.1 and d=0.5

Results:
- Average error as a function of the estimation round
- Simulated (MAC + routing + interference) performance

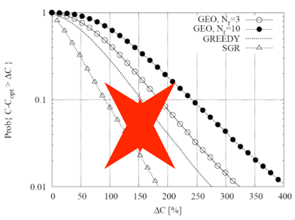
→ *Very good agreement between theory and practice*



Convergecasting

Simulation scenario:
- 15 nodes/coverage
- Cost ccdf, i.e., **Prob{ (path cost-optimal cost) ≥ ΔC }**

Considered Solutions:
- Geographical routing (**GeRaf**)
  - N_r = number of priority regions
- Hop count shortest path greedy routing (**GREEDY**)
- Hop count optimal Routing (**SGR**)

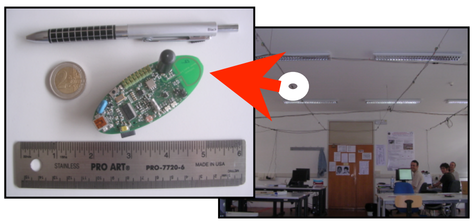


EYES PLATFORM

Node:
CPU MSP 430, 48KB ROM, 10 KB RAM
Radio TDA 5250, ASK/FSK 868 MHz
Operative System TinyOS

Testbed:
48 nodes within a 50 m² area

Testbed Manager:
Graphical Java Interface & debug tool



DEPARTMENT OF INFORMATION ENGINEERING
UNIVERSITY OF PADOVA

La Sapienza
Università degli Studi di Roma