

Energy Aware Routing for Low Energy Ad Hoc Sensor Networks

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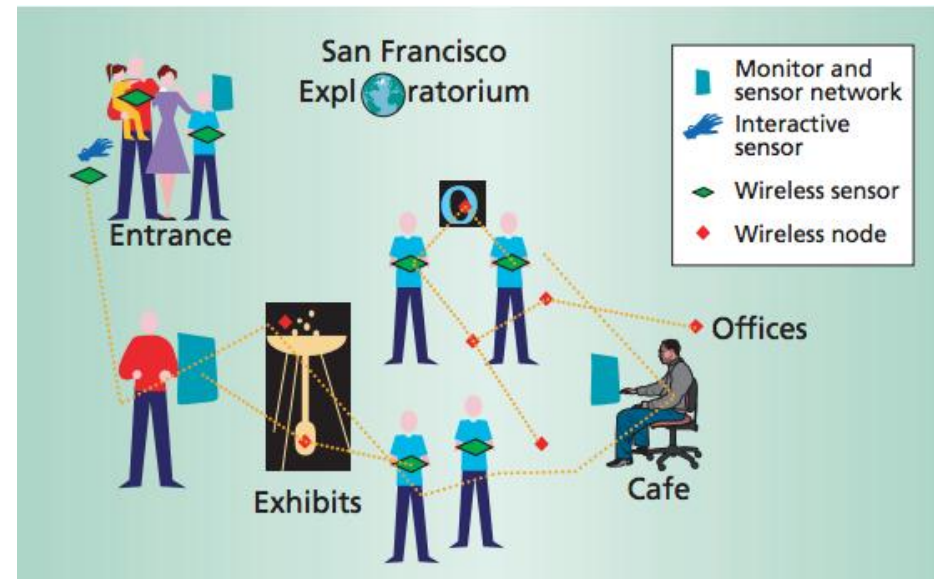
Presented by Eric Lam

Outline

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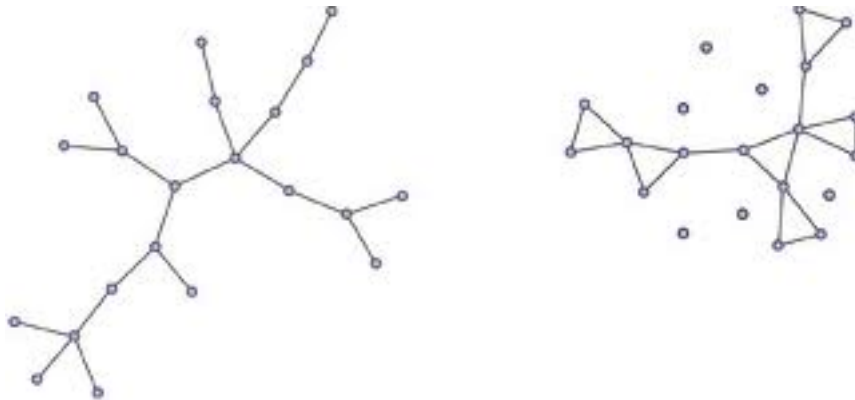
Motivation

- Goals of sensor networks
 - Small nodes
 - Cheap
 - Lightweight
 - Low-power
- Network survivability



Why do we care about network survivability?

- Always using the optimal path may create subnets
- Objective is to equitably burn energy throughout the network
- Increase time to network partition



What is Energy Aware Routing?

- Keeps a set of good paths
- Choose one probabilistically

PicoRadio

- Sensor network to control office environment
- Three types of nodes
 - Sensors
 - Controllers
 - Actuators
- Most nodes will remain static
- Peak bit rate of 10 kb/s



PicoRadio MAC Layer

- Coordinates channel assignment, access, power, and neighbor list management
- Global broadcast channel
- Keeps track of location
- Two radios per node
 - One low power, 100% duty cycle
 - One high power, low duty cycle (~1%)

PicoRadio Network Layer

- Geographically based addresses
- Class-based addressing <Location, Node Type, Node Subtype>

Routing Protocols

- Proactive routing protocols
 - Maintain up-to-date routing information
- Reactive routing protocols
 - Create routes on demand
 - Source-initiated or destination-initiated

Energy Aware Routing

- Reactive routing protocol that is destination-initiated
- Destination maintains routes
- Three phases
 - Setup phase
 - Data communication phase
 - Route maintenance

Energy Aware Routing – Setup Phase

- Destination floods network with request
- Intermediate nodes forward request to nodes closer to source node
- Path costs are then computed
- Paths below a minimum threshold are kept
- Assign probability to each path that is inversely proportional to cost and store into forward table
- Calculate average cost and continue forwarding to source node

Energy Aware Routing – Data Communication Phase

- Source sends data to randomly picked node in forwarding table according to the assigned probability distribution
- Each intermediate node does the same
- Continue until packet reaches destination
- Routes are maintained by periodically by flooding at the destination to keep paths alive

Energy Metric

- Different energy metrics can be customized to the application
- PicoRadio uses the following

$$C_{ij} = e_{ij}^a R_i^b$$

Simulation and Results

- 76 nodes consisting of light sensors, temperature sensors and controllers
- Send data every 10 seconds and temperature every 30 seconds
- MAC and physical layer provided direct transfer of packets in order to study network effects only

Simulation and Results

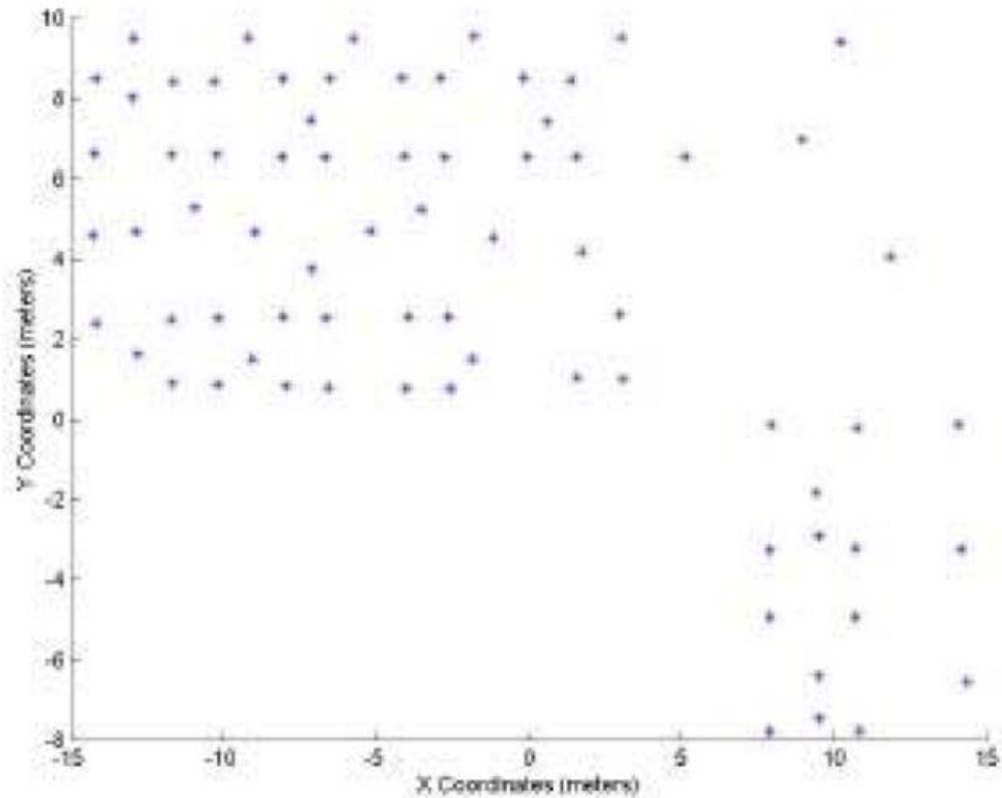


Fig. 1 Layout of static nodes in the network

Simulation and Results

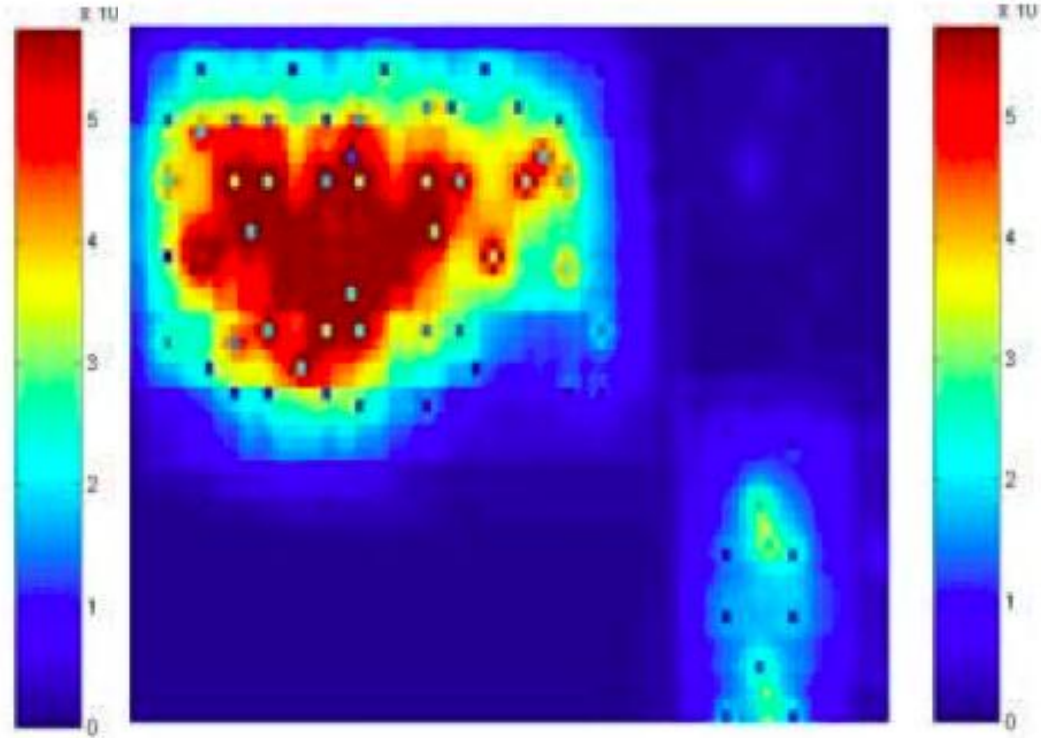
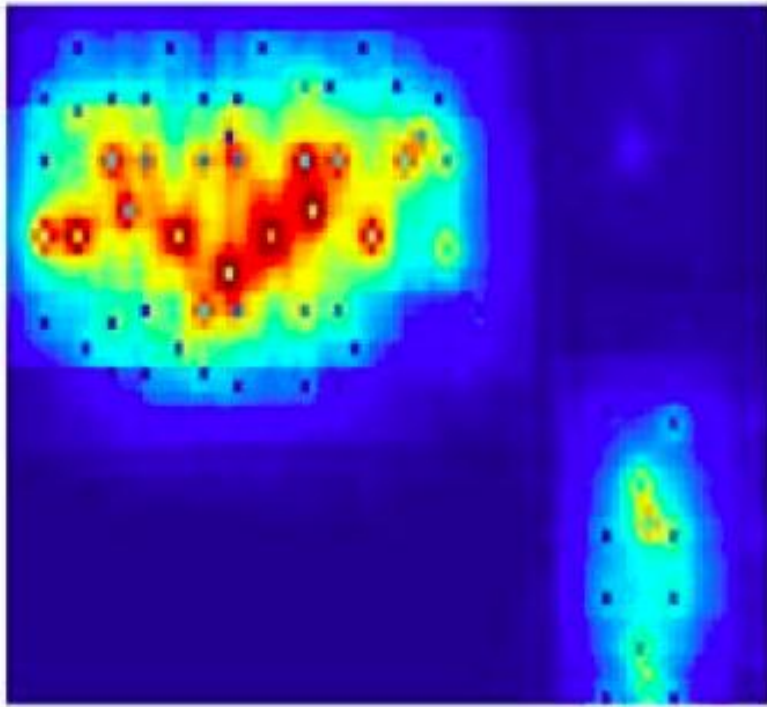


Fig. 2 Energy consumption for energy aware routing (μJ)

Fig. 3 Energy consumption for diffusion routing (μJ)

Simulation and Results

- Average energy consumption in diffusion was 14.99 mJ whereas energy aware routing was 11.76 mJ
- Improvement of 21.5%

Simulation and Results

- Diffusion routing took 150 minutes for a node to run out of energy whereas energy aware routing took 216 minutes
- 44% increase in network lifetime

Simulation and Results

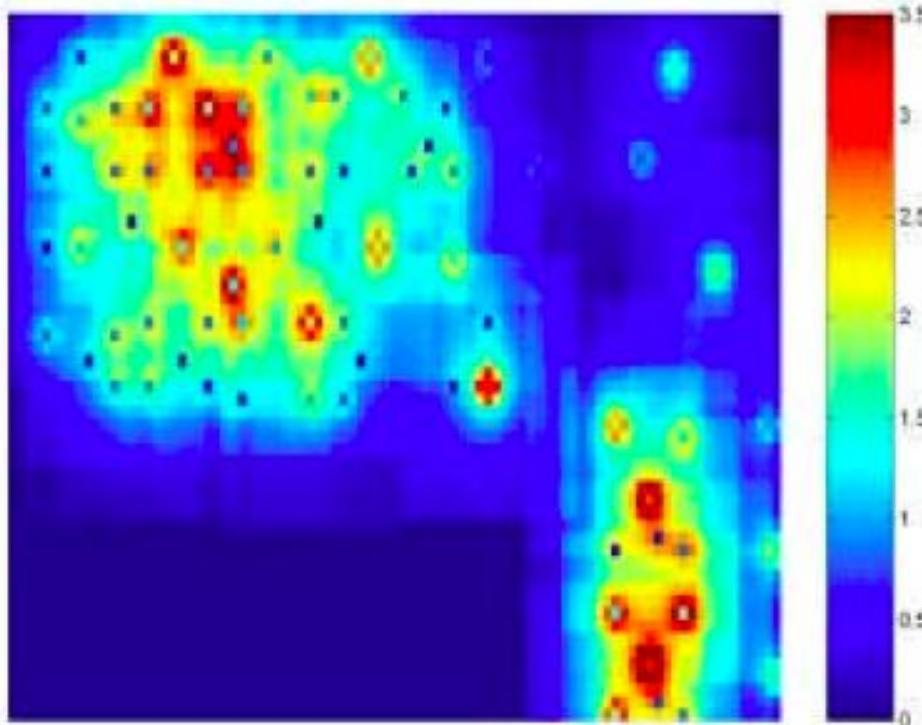


Fig. 4 Normalized energy for energy aware routing

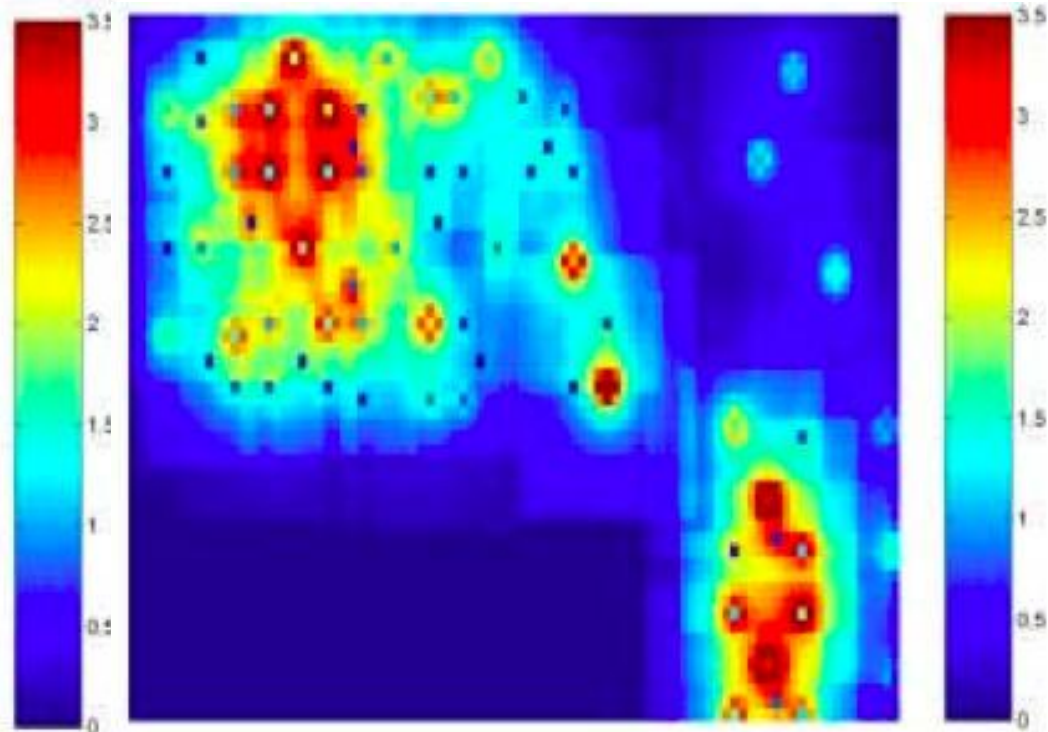


Fig. 5 Normalized energy for diffusion routing

Conclusion

- Energy aware routing can improve the connectivity and lifetime of a sensor network
- Always using the lowest energy path is not optimal for long-term health of the network