Energy Conservation in Sensor Networks through Selective Node Activation

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Content

- Problem definition
- Solution
- Cost

Problem definition

- Focus on the communication aspect of the network
  - Intermediate/peripheral nodes
- To reduce power consumption in facilitating communication between source nodes and the Cluster-head
  - *No coverage consideration.*

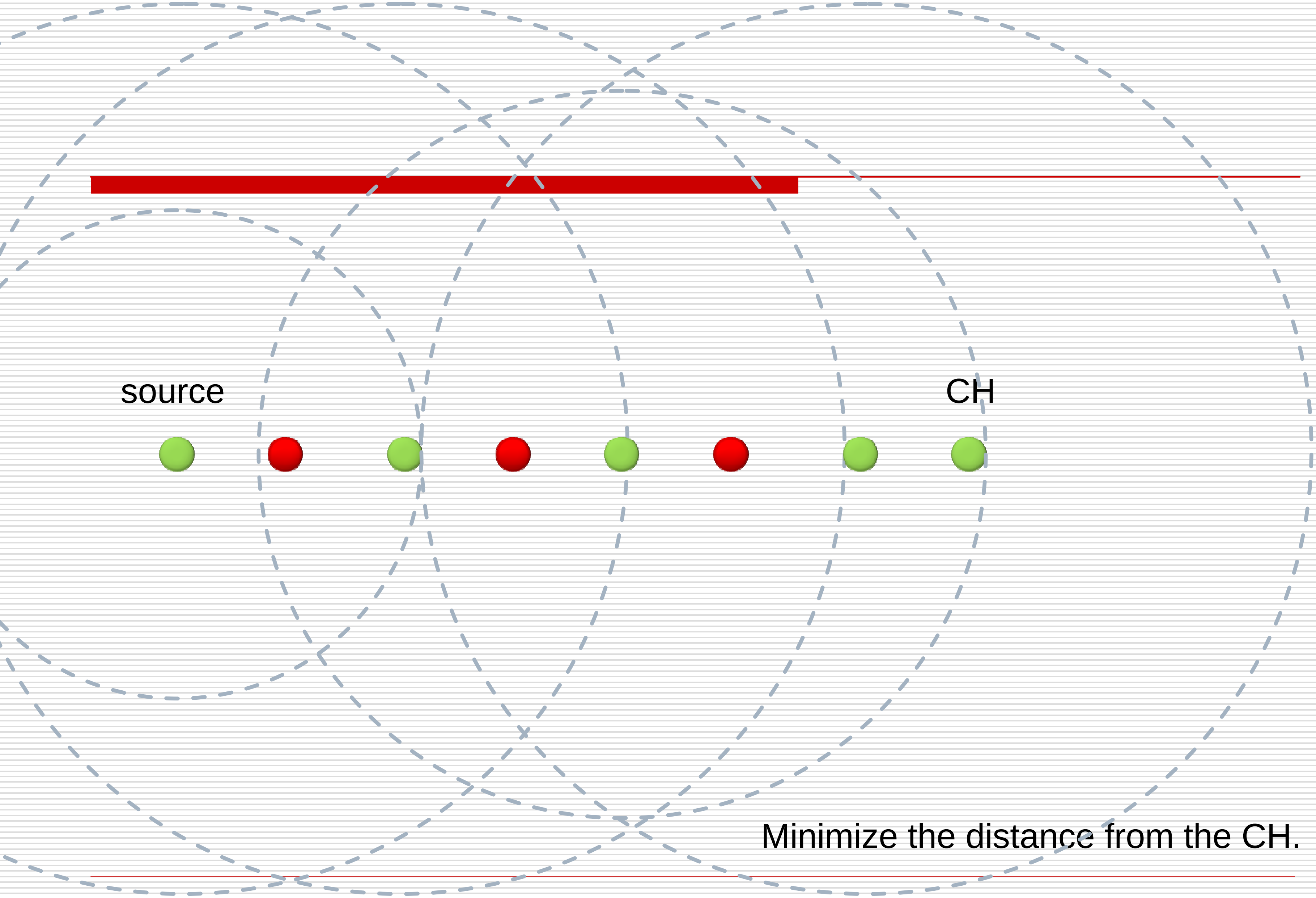
Assumptions

- One node has two states:
  - listening/inactive
  - Active

- $L << T + R$

Approach

- To eliminate the number of nodes participating in the network
  - Variable transmission range
    - i.e. Utilize a fixed fraction of its residual energy for each transmission.
  - Imposing a threshold
    - $[\Psi_{min}, \Psi_{max}]$
    - Activate node *k* if $\Psi_{min} <= \Psi_k < \Psi_{max}$, otherwise deactivate node *k*



Minimize the distance from the CH.

Solution

- Channel features
  - Fading gain (channel distortion)
  - Additive white Gaussian noise (*N(0,* σ_{η}^{2}*)*)

$$\Psi = 10\log_{10}\left(\Omega G_t G_r \left[\frac{h_t h_r}{D^2}\right]^{\alpha}\right) \text{ dBm}$$

$$\mu_r^{(2)} = \Psi + \sigma_\eta^2$$

- The average received power

$$\hat{\Psi} = \hat{\mu}_r^{(2)} - \sigma_\eta^2$$

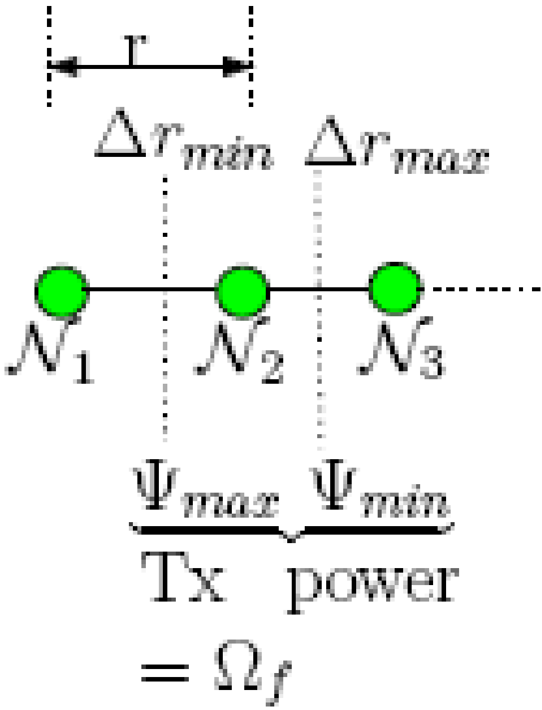
- The number of samples

$$N \approx \left(\frac{\delta \, \sigma_z}{\epsilon} \right)^2$$

  - $\Psi_{min} = \Psi - \varepsilon - \Delta_{min}$
  - $\Psi_{max} = \Psi + \varepsilon + \Delta_{max}$

Network layout

- Linear
  - $N_T^{Lin} = k$
- Hexagon
  - $N_T^{Hex} = 3k(k+1)$



$$\Delta r_{max} = \left(\frac{\Omega_f}{\Psi_{min}}\right)^{\frac{1}{4}}, \qquad \Delta r_{min} = \left(\frac{\Omega_f}{\Psi_{max}}\right)^{\frac{1}{4}}$$

$$\begin{aligned} r &= \Delta r_{min} + \frac{1}{2}(\Delta r_{max} - \Delta r_{min}) \\ &= \frac{1}{2}(\Delta r_{max} + \Delta r_{min}) \end{aligned}$$

Cost

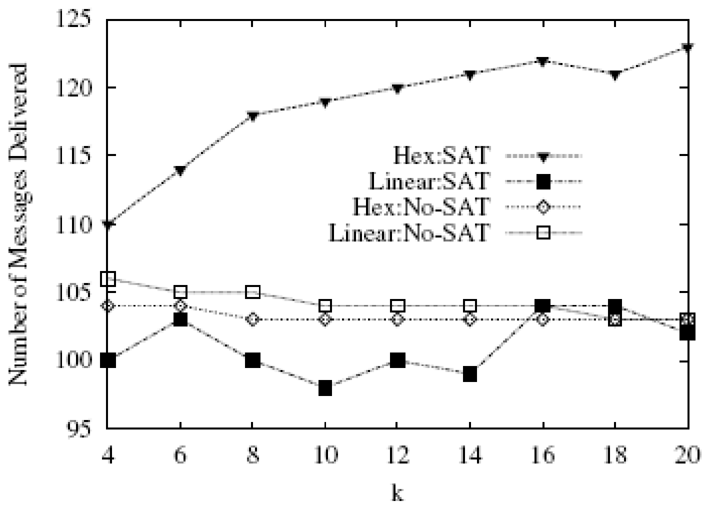
- The total cost and saving per transmission
  - L, T and R are energy consumed during Listen, Transmission and Receiving data.

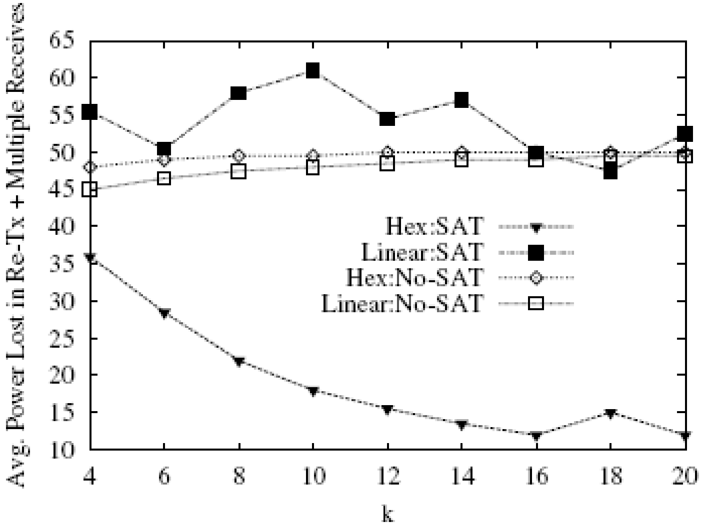
$$\mathcal{C}_{tot}^{SAT} = \sum_{\mathcal{H}} \mathcal{L}N_{T}^{Lin} + \sum_{\mathcal{H}} \mathcal{T} + \sum_{\mathcal{H}-1} \mathcal{R}N_{A}^{Lin} \quad (18)$$

$$= \left(\mathcal{L}N_{T}^{Lin} + \mathcal{T}\right) \frac{\mathcal{H}(\mathcal{H}+1)}{2} + \mathcal{R}N_{A}^{Lin} \frac{\mathcal{H}(\mathcal{H}-1)}{2}$$

$$\mathcal{S}_{tot}^{SAT} = \sum_{\mathcal{H}-1} \mathcal{R}N_{I} = \mathcal{R}N_{I}^{Lin} \frac{\mathcal{H}(\mathcal{H}-1)}{2}$$

Simulation


Number of Messages Delivered
125
120
115
110
105
100
95
Hex:SAT
Linear:SAT
Hex:No-SAT
Linear:No-SAT
4 6 8 10 12 14 16 18 20
k


Avg. Power Lost in Re-Tx + Multiple Receives
65
60
55
50
45
40
35
30
25
20
15
10
Hex:SAT
Linear:SAT
Hex:No-SAT
Linear:No-SAT
4 6 8 10 12 14 16 18 20
k