A Practical Approach to Deploy Large Scale Wireless Sensor Networks

Wireless Seminars

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Article Reference

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Pages 243-250

Introduction

- WSN → Sensor: Measures + Relays data
- Sensing workload is the same among sensors
- Relaying workload differs
  - Sensor closer to sink carry more traffic
  - The lifetime would be shorter
- The network degrades unevenly
- In areas were sensors die early
  - Less data will be collected
  - Data from other sensors could not reach the sink
  - Locate sensors to replenish

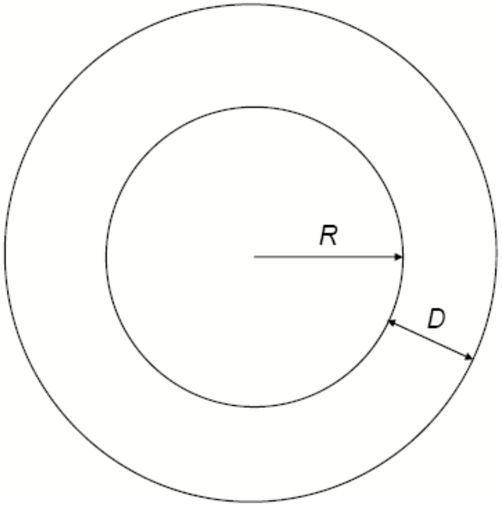
Introduction

- Possible solution → Deploy more sensors near the sink
  - Extra sensing capabilities are wasted
  - Network becomes non-uniform
- Evenly distributed sensors and life time
- Dedicated relaying nodes (routers)
- Sensors collect data and transmit it to the routers
- Routers only relay data from sensors/routers to other routers
- How to deploy the routers?

Sensor lifetime

- Consider all sensors are equal
- Lifetime:

$$L = \frac{E}{W_0 + r_1\left(W_1 + \frac{W_2}{\left(1+\frac{D}{R}\right)^2 - 1}\right)}.$$



- R ↑
  - Lifetime ↓
  - Data losses due to buffer size/data rate

Designated Relaying Nodes

- Router does not measure data
- Collects data from sensors and routers and sends it to other routers to the sink
- Mesh topology (Large Scale WSN)
- Deployment of the routers
- Assumes routers are battery powered
  - Usually are mainline powered
- We could afford uneven router deployment
  - The number of routers is far less than the number of sensors
  - They do not sense data

Designated Relaying Nodes

- Energy consumption of the sensors:
  - It is the same except to send data (distance)
- Energy consumption of the routers:
  - Energy used to forward each bit of data

$$E = a_1 + a_2 d^n$$

  - Energy consumption rate

$$P = \left(a_1 + a_2 d^n\right) r$$

- Deployment method so that *P* is the same among routers

Examples of Router Deployment

- Examples of shapes
- Three methods for each shape

R: The radius of a circular area or the length around an area.

D_s: the sensor deployment density.

D_r: the router deployment density.

r_s: the sensor data generation rate.

d: the distance between two sub-regions.

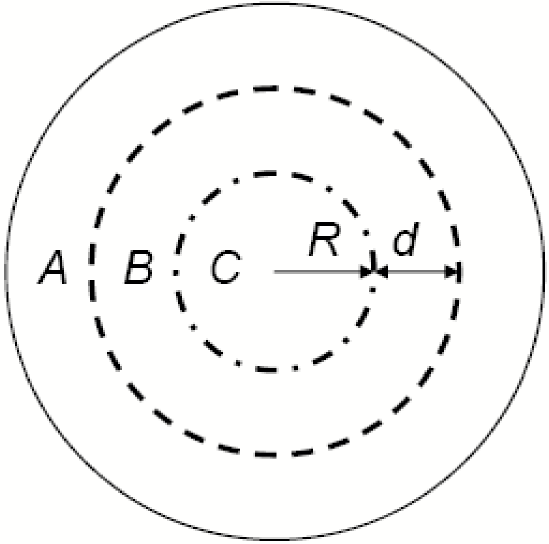
w: the width of the router deployment line.

N: the total number of routers deployed.

A, B, C: the names of areas in consideration.

Examples of Router Deployment

- Round Region with Sinks at the Border
  - Equal distance
    - Select *d* and *P*
    - Compute the Number of routers at each circle



$$\pi R^2 D_s \qquad \pi R^2 D_s r_s$$

$$2\pi R D_r \qquad (\pi R^2 D_s r_s) / (2\pi R D_r)$$

$$(R D_s r_s) / (2 D_r)$$

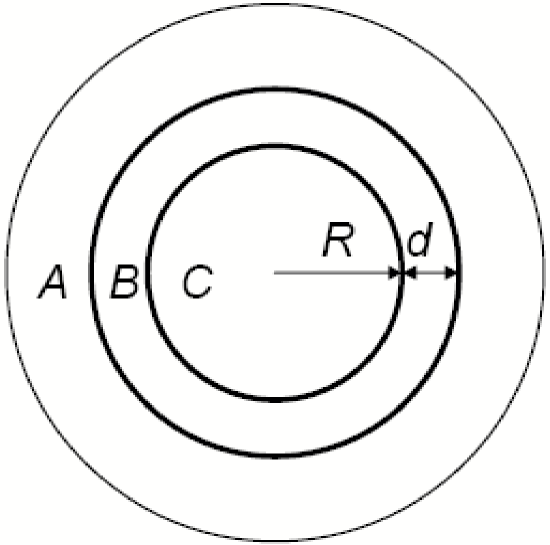
$$P = R D_s r_s (a_1 + a_2 d^n) / (2 D_r)$$

$$D_r = R D_s r_s \left(a_1 + a_2 d^n\right) / (2P)$$

Examples of Router Deployment

- Round Region with Sinks at the Border
  - Equal density
    - *d* will decrease as *R* increases
    - Compute *d*

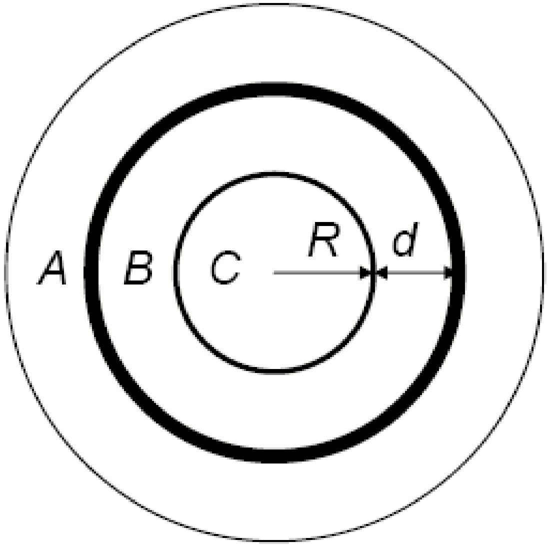
$$P = RD_s r_s(a_1 + a_2 d^n) / (2D_r)$$



$$d = \sqrt[n]{\frac{\frac{2PD_r}{RD_s r_s} - a_1}{a_2}}$$

Examples of Router Deployment

- Round Region with Sinks at the Border
  - <u>Equal distance and density</u>
    - We increase the circle width
    - The circle width has to increase linearly



$$\pi R^2 D_s \qquad \pi R^2 D_s r_s$$

$$2\pi R w D_0 \quad (\pi R^2 D_s r_s) \;/\; (2\pi R w D_0)$$

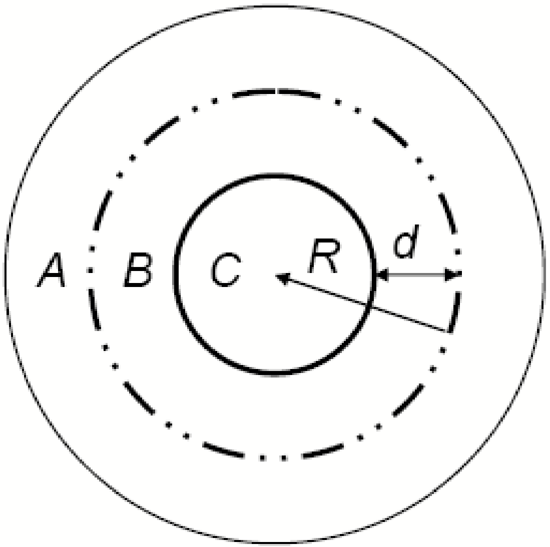
$$(R D_s r_s) \;/\; (2 w D_0)$$

$$P = R D_s r_s (a_1 + a_2 d^n) \;/\; (2 w D_0)$$

$$w = R D_s r_s \left(a_1 + a_2 d^n\right) / \left(2 P D_0\right)$$

Examples of Router Deployment

- Round Region with Sinks at the Center
  - Equal distance
    - Select *d* and *P*
    - Compute the Number of routers at each circle



$$\pi(R_0^2 - R^2)D_s \quad \pi(R_0^2 - R^2)D_s r_s$$

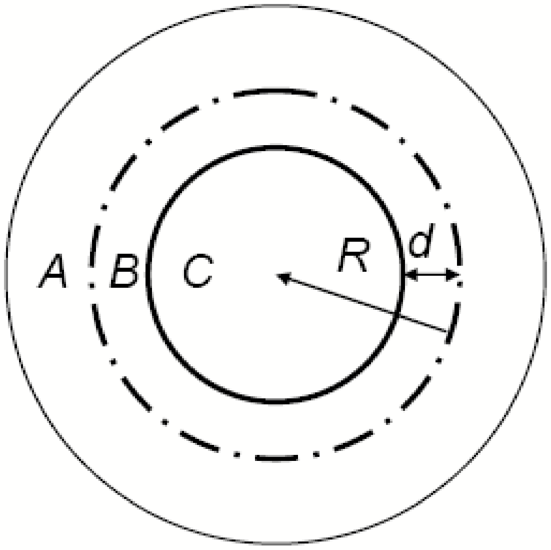
$$2\pi R D_r \quad \pi(R_0^2 - R^2)D_s r_s / (2\pi R D_r)$$

$$P = (R_0^2 - R^2)D_s r_s(a_1 + a_2 d^n) / (2RD_r)$$

$$D_r = \left(R_0^2 - R^2\right)D_s r_s\left(a_1 + a_2 d^n\right)/\left(2PR\right)$$

Examples of Router Deployment

- Round Region with Sinks at the Center
  - Equal density
    - We could not achieve equal density if width is equal to 1
    - Routers in the inner circles have to relay more data
    - But the size of the inner circles is smaller than outer



Examples of Router Deployment

- Round Region with Sinks at the Center
  - Equal distance and density
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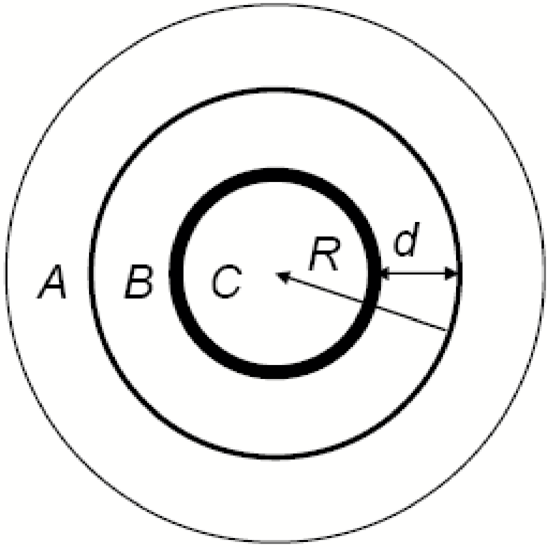
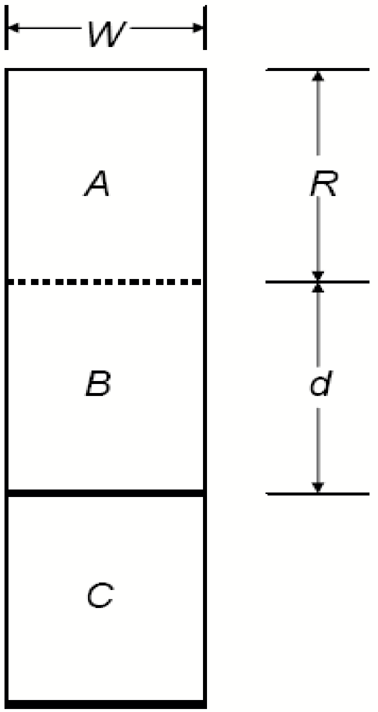


$$w = \left(R_0^2 - R^2\right) D_s r_s \left(a_1 + a_2 d^n\right) / \left(2PRD_0\right)$$

Examples of Router Deployment

- Rectangular Region with Sinks at the Bottom
  - Equal distance
    - Select *d* and *P*
    - Compute the Number of routers at each line



$$RWD_s \qquad RWD_s r_s$$

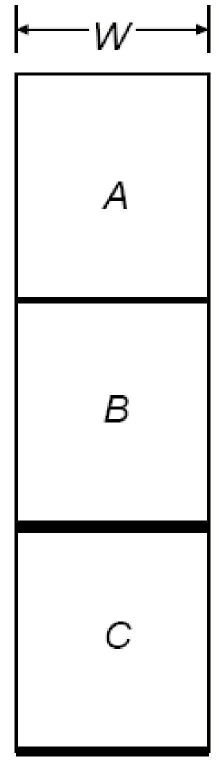
$$WD_r \qquad RD_s r_s / D_r$$

$$P = RD_s r_s (a_1 + a_2 d^n) / D_r$$

$$D_r = RD_s r_s \left(a_1 + a_2 d^n\right) / P$$

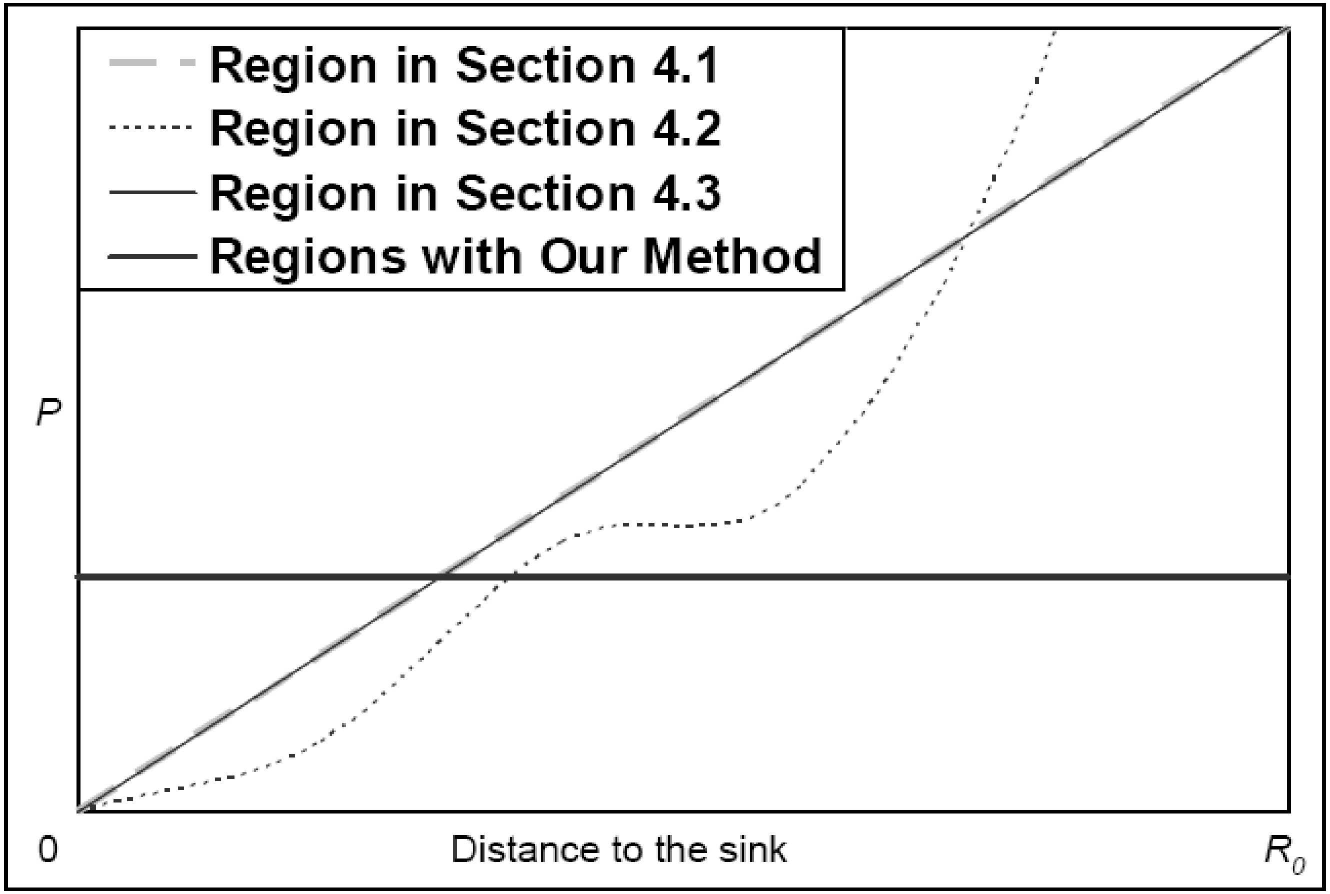
Examples of Router Deployment

- Rectangular Region with Sinks at the Bottom
  - Equal distance and density
    - We could not achieve equal density with width equal to 1



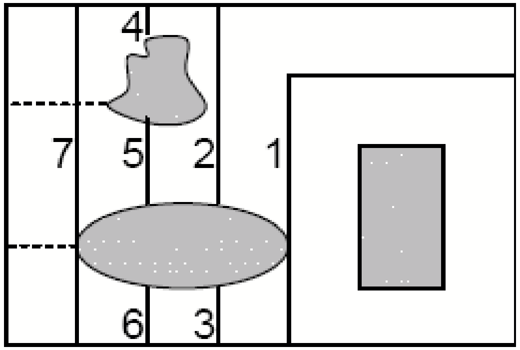
$$w = RD_s r_s \left(a_1 + a_2 d^n\right) / PD_0$$

Comparison with evenly deployment



Irregular Regions

- In practice the monitored region is not a perfect shape
- Simple method
  - Draw lines with the same distance
  - For each line compute the router density factor
    - Length of the line / Size of the sensor area it covers
  - Deploy routers on the lines with density $D_r = fD_0$



Conclusions

- Easy to deploy, maintain and replenish methods
- Expect even workload
- Two layered approach
- All routers in a sub-region have to share sensors equally
- A router has to receive data from routers equally

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