Fast Interference-Aware Scheduling of Multiple Wireless Chargers

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Outline

- Background and contributions
- Model and problem formulation
- Algorithm design
- Performance evaluation
- Conclusion

Background

- Wireless Sensor Network
  - Sensors are powered by small batteries;
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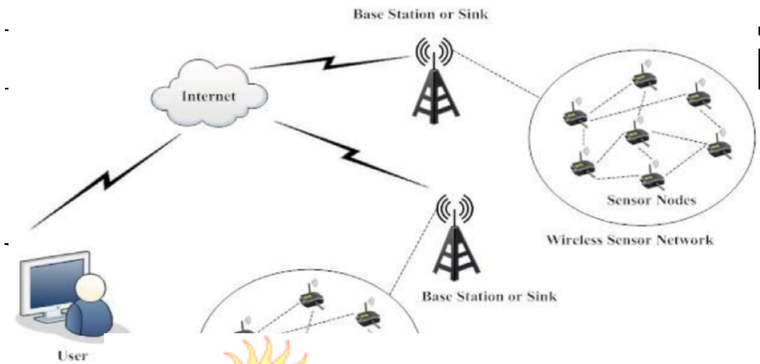
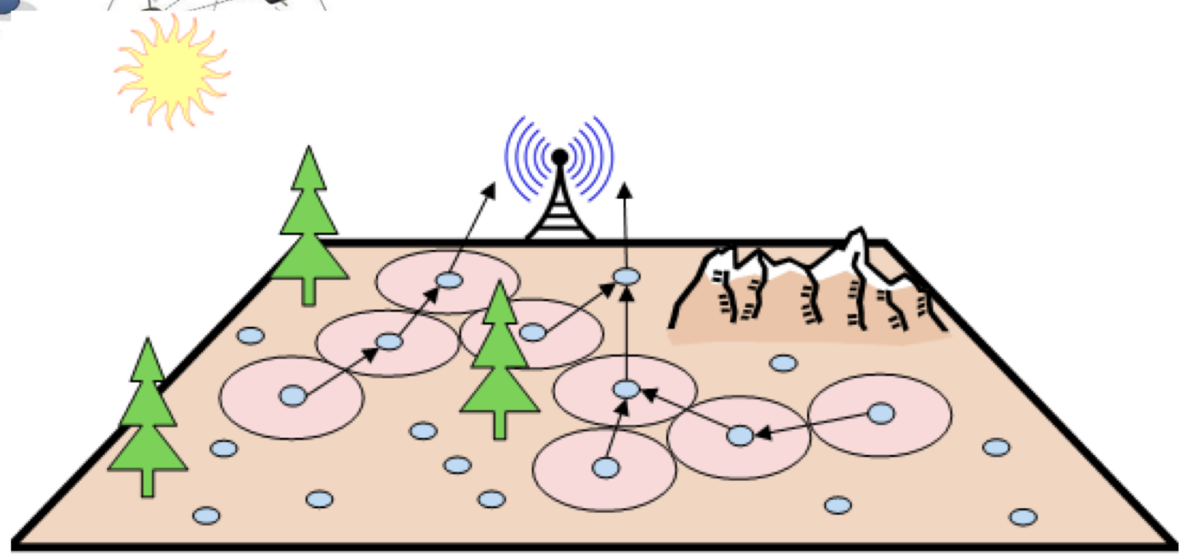
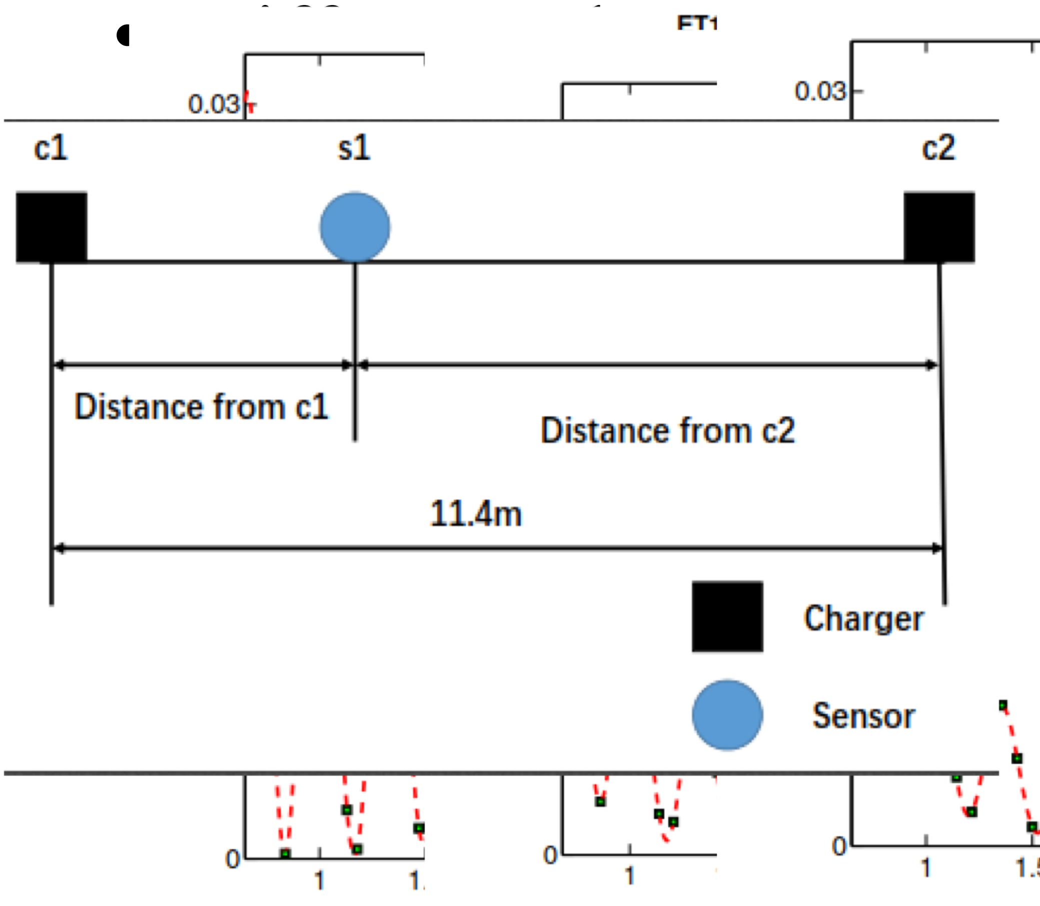
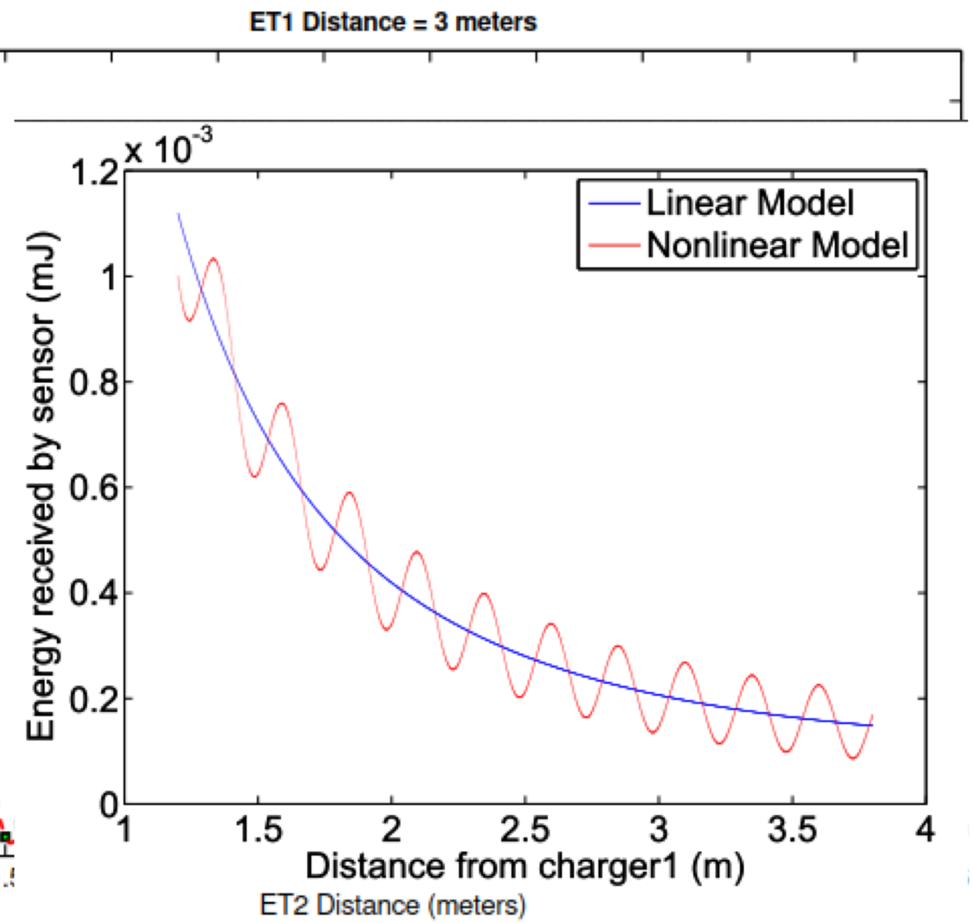




Background

- Combined energy
  - Combined energy is additive?





Background

- Related work:
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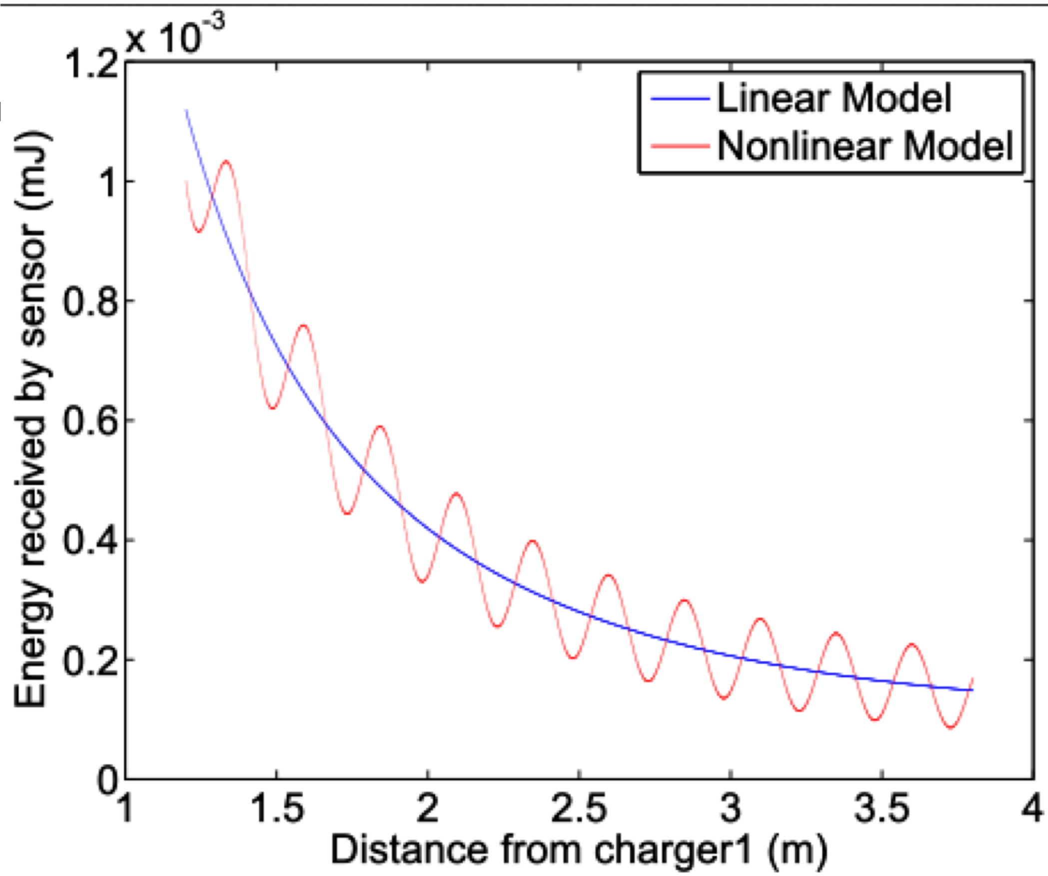
  → ...ber of chargers
- D...
  –



Contributions

- We apply a new charging model with nonlinear super-position into the FCS problem →NP-comlete;
- We propose FastPick algorithm in 1D line → bound (2-Є);
- We propose RoundPick algorithm in 2D network → bound;

Models

- Network model
  - N stationary sensor nodes $\{s_1, s_2, \ldots, s_n\}$ and M chargers $\{c_1, c_2, \ldots, c_m\}$
- Charging model
  - frequency component ω_0, amplitude A_0, initial phase φ_0, power attenuation factor 2
  - Radio signal received by sensor from charger c_i

$$a_{i0}(t) = \frac{A_0}{4\pi d_{ij}/\lambda} cos(\omega_0 t + \varphi_0 - 2\pi \frac{d_{ij}}{\lambda})$$

  - Radio signal received by sensor s_j from charger set C

$$A_0^j(t) = \sum_{c_i \in C} a_{i0}(t) = \sum_{c_i \in C} \frac{A_0}{4\pi d_{ij}/\lambda} cos(\omega_0 t + \varphi_0 - 2\pi \frac{d_{ij}}{\lambda})$$

Models

- Charging model
  - Power received by sensor s_j from charger set C

$$P_{j|C} = \int \overline{[A_0^j(t)]^2} d_\omega$$
$$= P \sum_{c_i \in C} \frac{1}{d_{ij}^2} + P \sum_{c_i \in C} \sum_{\substack{c_m \in C \\ c_m \neq c_i}} \frac{1}{d_{ij} d_{mj}} cos(2\pi \frac{d_{ij} - d_{mj}}{\lambda})$$

  - where $P = \int p_i d_\omega$, $p_i = \frac{A_i^2}{2}$

Models

- Harvesting model
  - Threshold of power: ϵ
  - Energy capacity: E

$$e_j|_{C,t} = \begin{cases} 0 & if\ P_j|_C < \epsilon \\ 0 & if\ P_j|_C > \epsilon \quad and \quad e'_j > E \\ \alpha t(P_j|_C - \epsilon) & otherwise \end{cases}$$

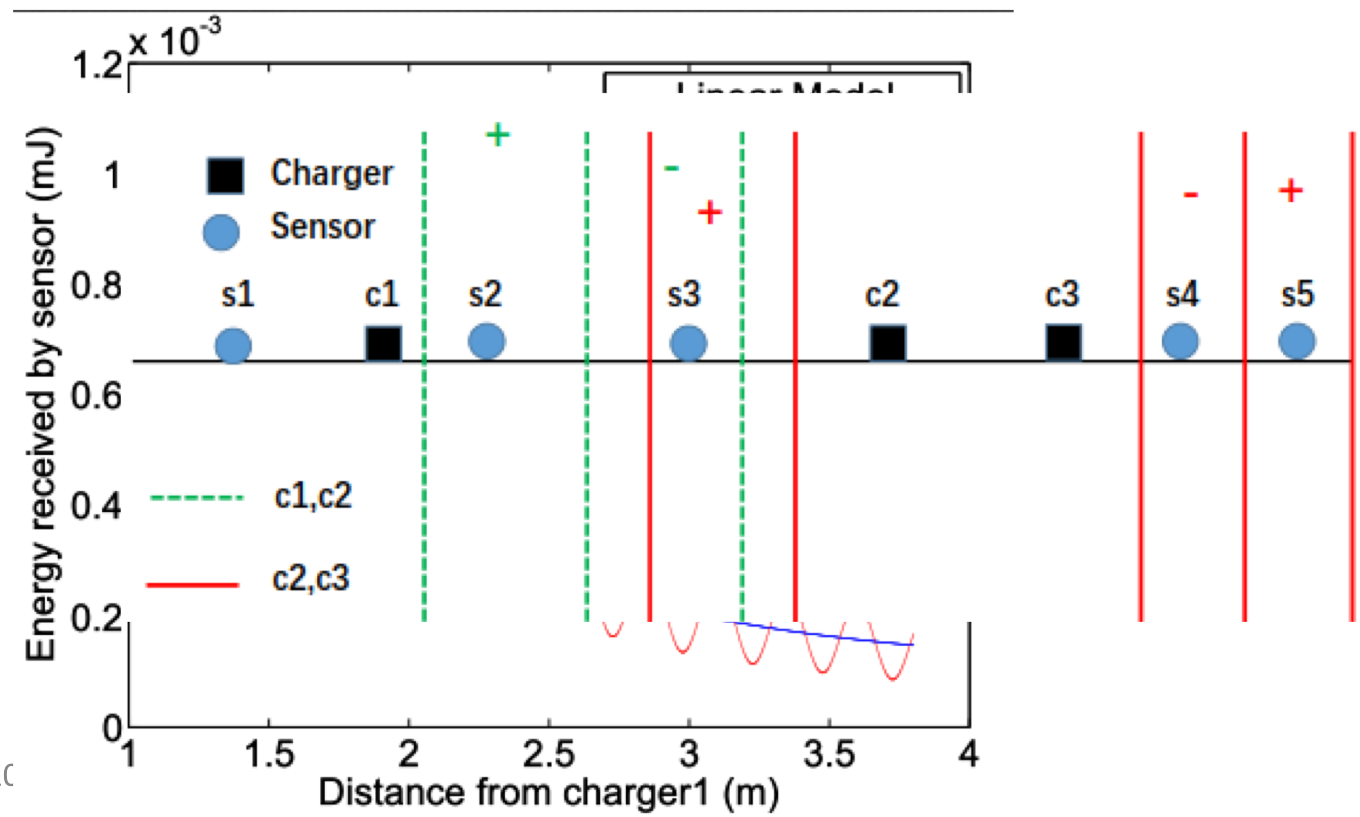
Problem Formulation

- We use H_i to denote i_{th} charging schedule
  - $H_2 = \{1,0,1,0\}$;
  - Δ denotes charging duration.

- Problem:
  - Given a set C of chargers with fixed position, a set S of rechargeable sensors, a set $\{d_{ij} \mid 1 \le i \le N, 1 \le j \le M\}$ of distance between ci and sj, and an energy capacity E of each sensor, FCS is to find a set of multiple charging schedules $\{H_1, H_2, \dots, H_k\}$, to charge each sensor with energy no less than E, and k is minimized.

One-Dimension Line

- Rational
  - Assumption: all frequency are the same;
  - Observation: difference of phases between two chargers



One-Dimension Line

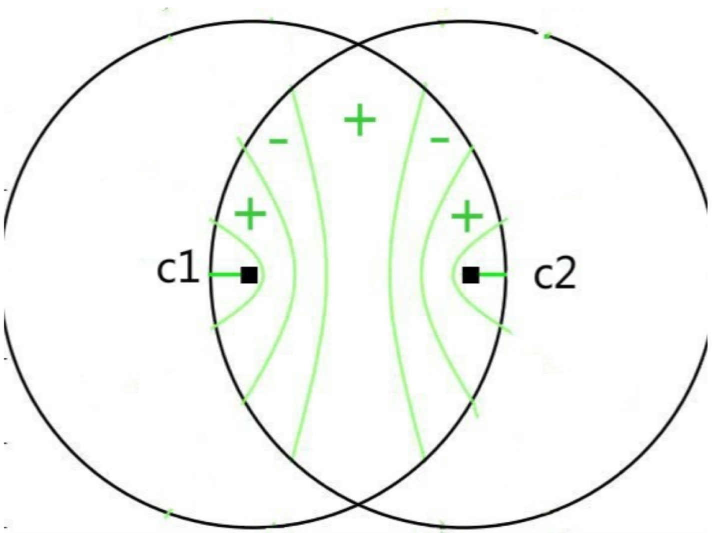
- FastPick (Initial phases are adjustable)
  - Choose the sensor with the least energy;
  - Find two chargers that are closest to this sensor;
  - Adjust their initial phases to make most sensors lie in their strong areas;
  - Adjust other chargers' initial phases to make the strong and weak areas are the same;
  - Reverse the original weak and strong areas.

One-Dimension Line

- Approximation Ratio
  - Lower bound: T (All chargers strengthen each other);
  - FastPick is at most 2 times longer than T;
  - T is smaller than OPT;
  - FastPick is 2-ε approximate.

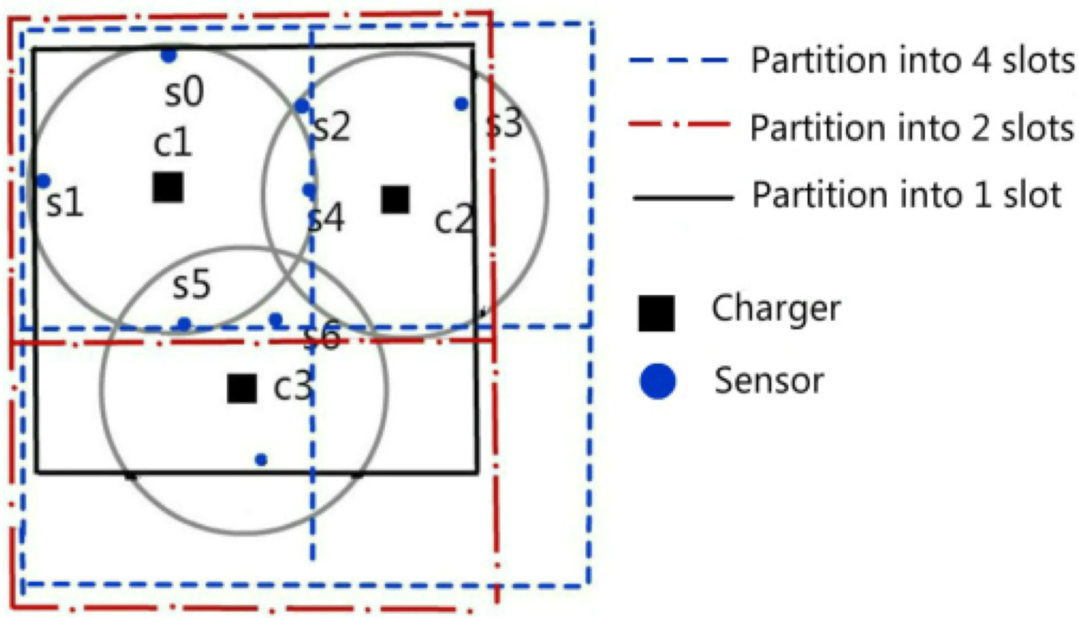
Two-Dimension plane

- Challenges
  - Irregular;
  - Two directions;
  - Cannot coincide.



Two-Dimension Plane

- Partition
  - Every sensor in one slot should be covered by chargers in this slot;
  - There is at least one charger in a slot;
  - The length of slot side should be minimized, but no less than 2 ∗ R (R
    i

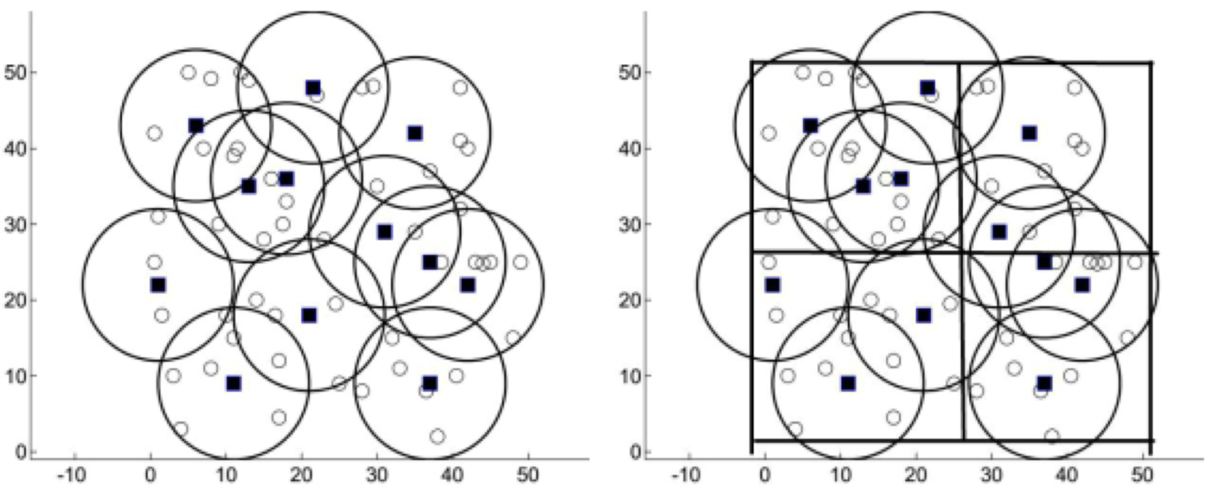


Two-Dimension Plane

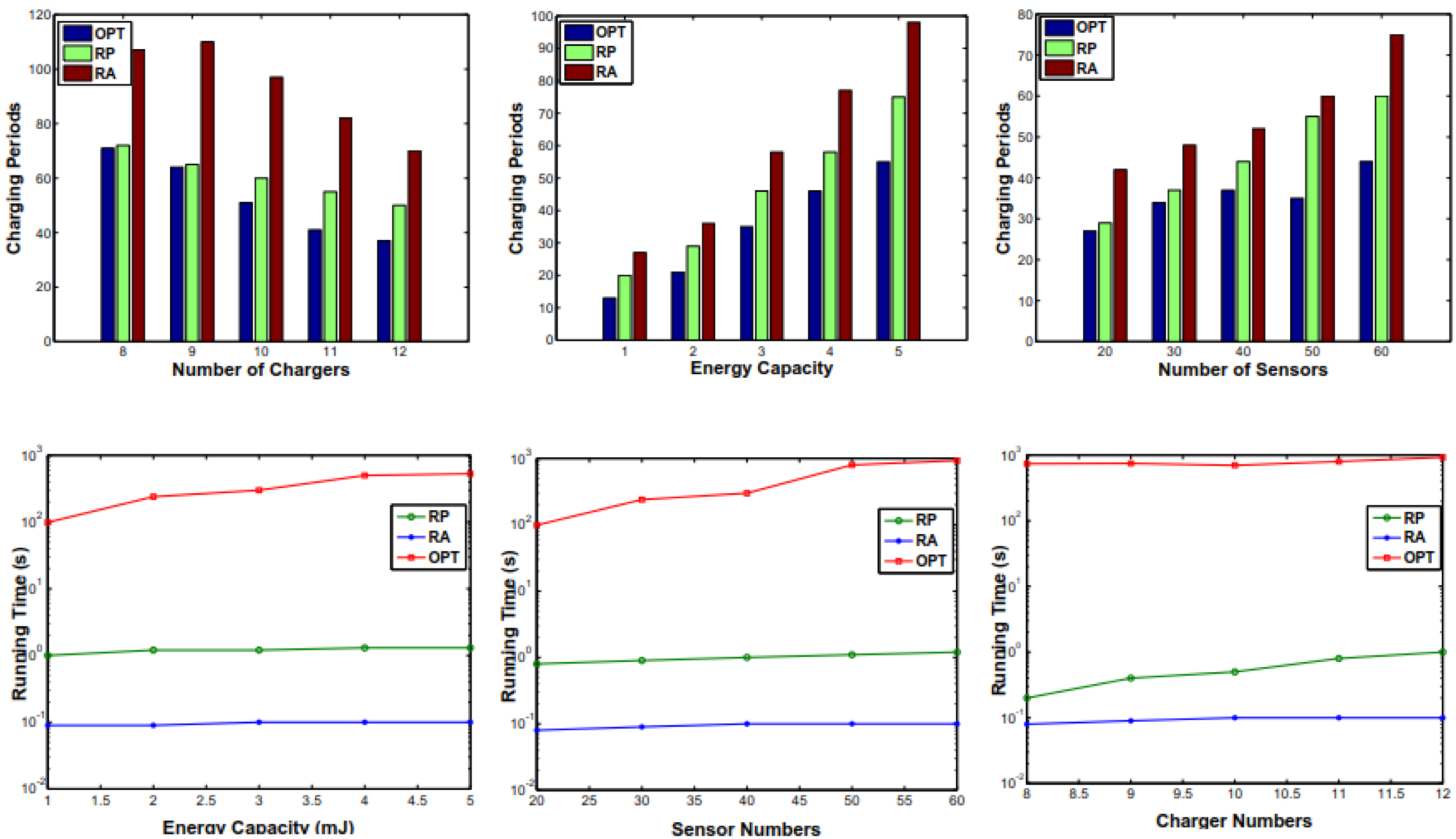
- RoundPick
  - Partition the network;
  - In each iteration, algorithm first computes each two chargers strong areas in each slot, then chooses a sensor with the least energy;
  - Add new chargers if more energy would be received;
  - Move slot.

  - We also get a bound of 6-4ε

- Settings
  - Wave … uW,
    transi …
  - Dista …
  - Defau … mJ.



Evaluations



Thank you

Q&A