Approximation Algorithm for Maximum Lifetime in Wireless Sensor Networks with Data Aggregation

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Presented by

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Outline

- Network Model
- Contribution and related work
- Centralized algorithm
- Conclusions and future work

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Network Model

- Sensor is on all the times
- Sensor's location is known
- Adjustable communication range
- Stationary
- Report to Base station directly or via other sensors as relays
- Data aggregation capability

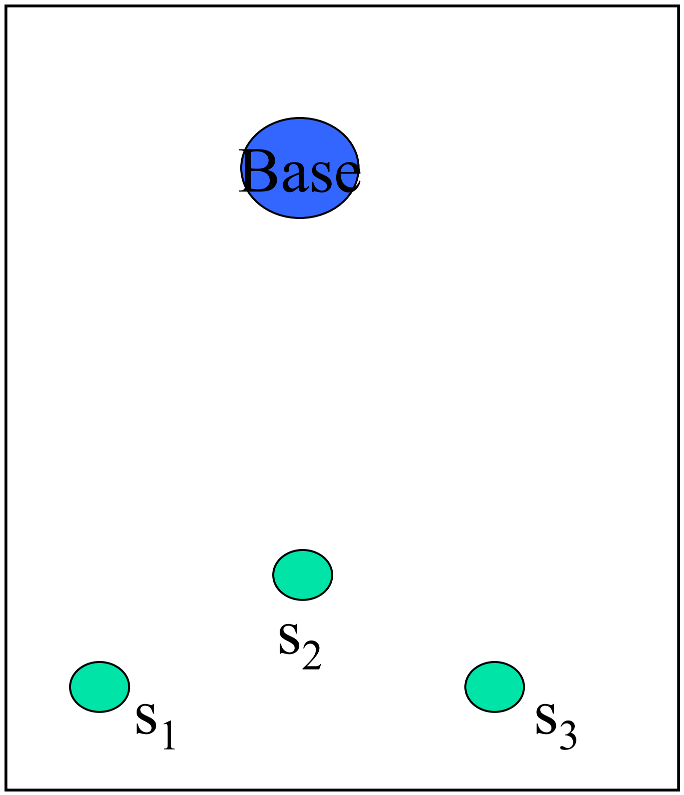
Contribution and related work

- Contribution
  - Centralized algorithm with approximation ratio
- Related work

Protocols/algorithms	By	Centralized/Distributed
1.MLDA	K.Kalpakis, K.Dasgupta, and P.Namjoshi	Centralized
2.LEACH	W.Heinzelman, A.Chandrakasan, and H.Balakrishnan	Distributed
3.PEGASIS	S.Lindsey and C.C.Raghavendra	Distributed

Centralized algorithm

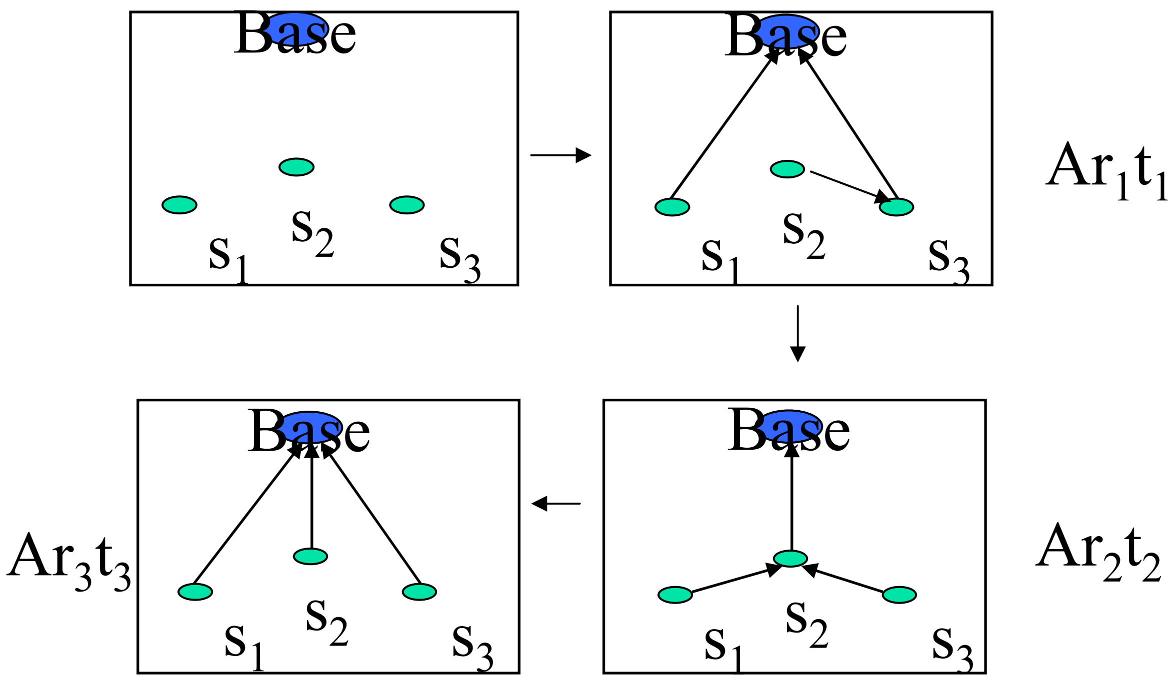
- Maximize Total time until the first sensor runs out of energy



Problem formulation

- Lifetime Maximization problem – To find a monitoring schedule $\{(Ar_1,t_1),\ldots,(Ar_k,t_k)\}$
  - *Max* $\Sigma\, t_{Ar}$
    - *s.t.* $\Sigma P_{Ar}(v_i)\, t_{Ar} \leq E(v_i)$
    - $P_{Ar}(v_i)$ = *TX*(v_i,v_j=*parent of* v_i *in Ar*)+(#*children of* v_i *in Ar*)*RX*
- Exact algorithm called MLDA (K.Kalpakis, K.Dasgupta, and P.Namjoshi)
  - $O(n^{15}\log n)$

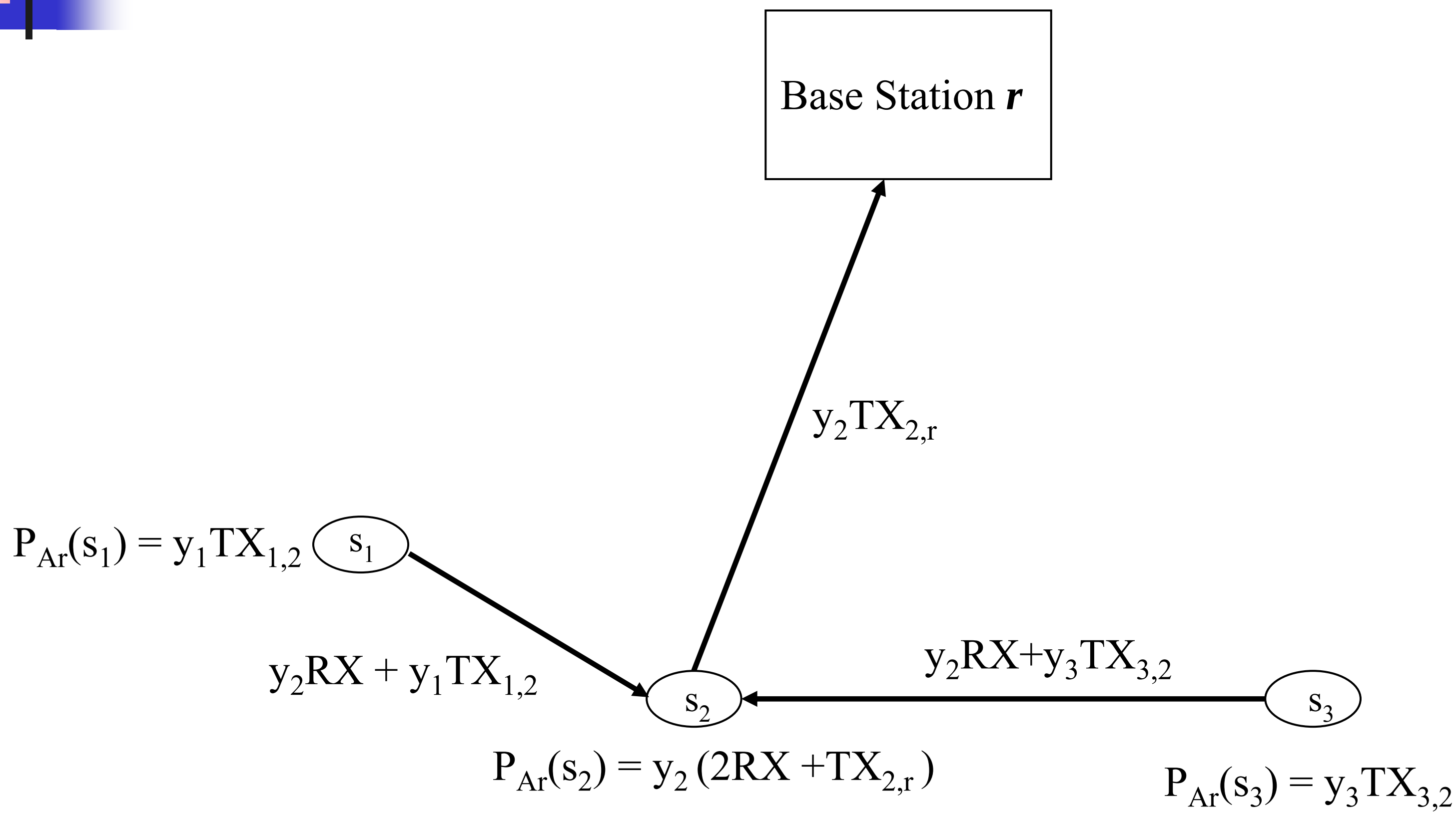
Example schedule



Approximation algorithms

- Heuristics (K.Kalpakis, K.Dasgupta, and P.Namjoshi)
  - G-CMLDA
  - I-CMLDA
- Garg-Könemann approx. alg. with minimum length columns
  - Find *Ar* that Minimizes $\Sigma P_{Ar}(v_i)\, y_i$
  - Minimum cost spanning arborescence problem

Problem reduction



Approximation ratio

- (1-ε) Garg-Könemann approx. alg.
  - Exact algorithm of finding minimum cost spanning arborescence
  - (1-ε) approximation ratio
  - $O(n^3 \, 1/\varepsilon \, \log n)$ complexity

Experimental information

- 40, 50, and 60 nodes in $50 \times 50 m^2$
- Base station is at (25,150)
- Initial energy is 1 J.
- Receiving power consumption
  - 50 nJ/bit
- Transmitting power consumption
  - 50 nJ/bit + $100 * d^2$ pJ/bit
- Package size 1000 bits

Experimental result

Algorithm	Quality	Running time
OPT (MLDA)	1	1
G-CMLDA	0.91	0.1
I-CMLDA	0.97	0.33
GK	0.975	0.07

$\varepsilon = 0.1$

Conclusions and Future work

- Conclusion
  - Centralized algorithm with (1-ε) approximation ratio
  - Actual results on average within 2.5% of optimum
  - Running time on average within 7% of one for finding optimum
- Future work
  - Implement faster minimum cost arborescence algorithm
  - Methods, tools for finding optimum of large sensor networks
    - CPLEX on 80 nodes takes 28.5 hours

Questions?

Thank You