Path Update Algorithms for Mobile Nodes in a Wireless Ad Hoc Sensor Network

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CS428 – Project Presentation

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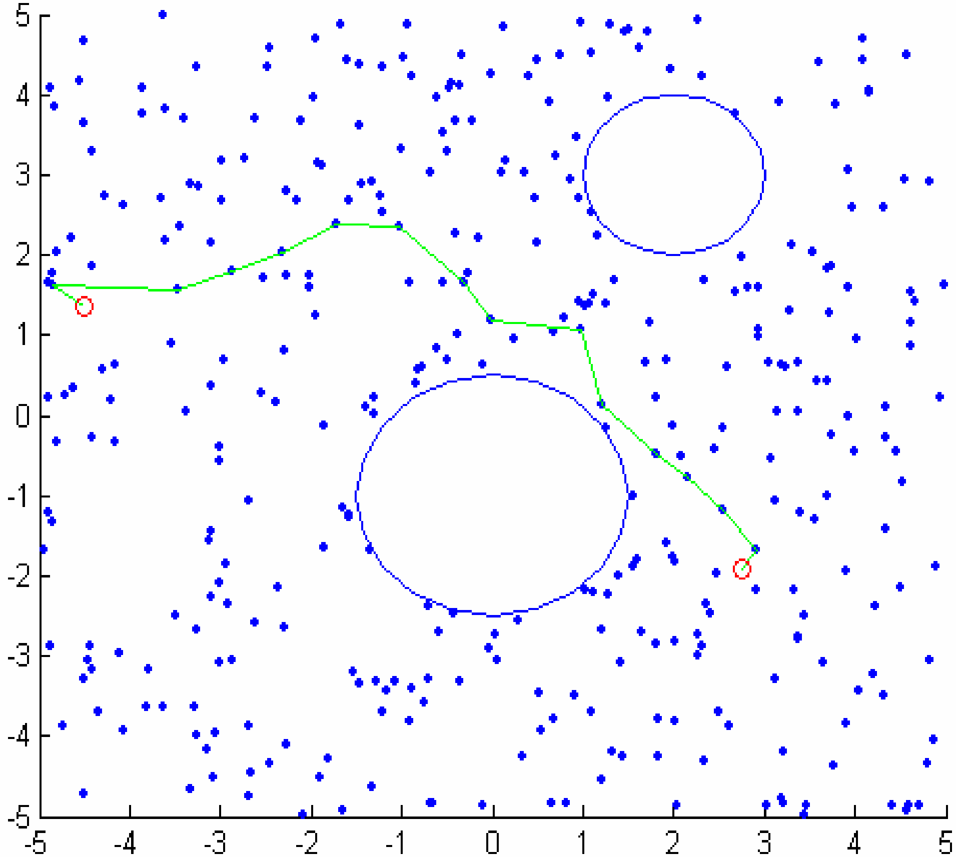
Assumptions

- A path exists between the two mobile agents
- Connectivity is preserved
- Position of the mobile agents do not change during a search. (i.e, they move slow enough)
- Mobile Agents do not act as routers
- Local-handoff is sufficient to maintain connectivity.

Scenario-Example



Ad hoc Vs. Optimum Routing

Objective :

To minimize total energy usage in searching for a path and communication over a path.

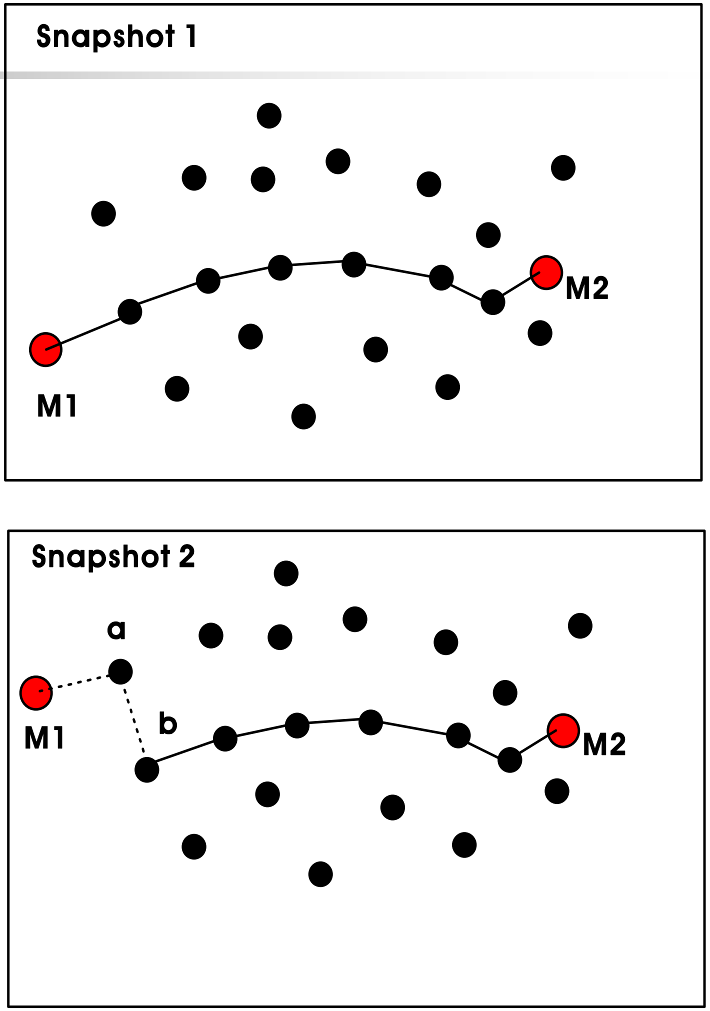
- Low data rate - can use ad hoc routing.
- High data rate – need energy efficient paths.

(Data rates - low and high w.r.t the avg velocity of the agents)

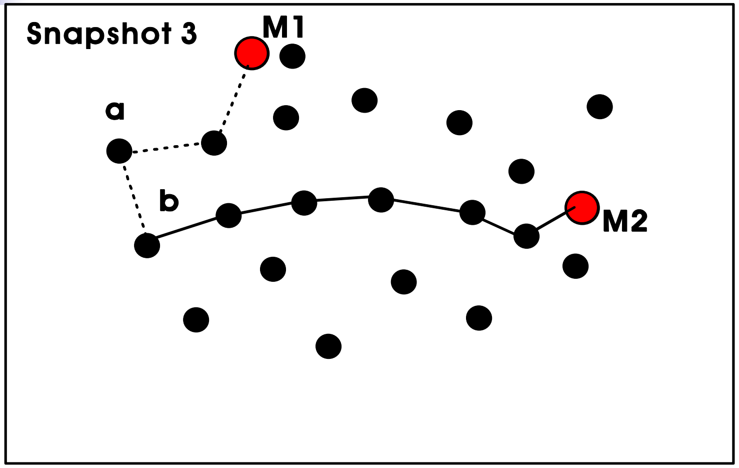
Local One-Hop Optimization

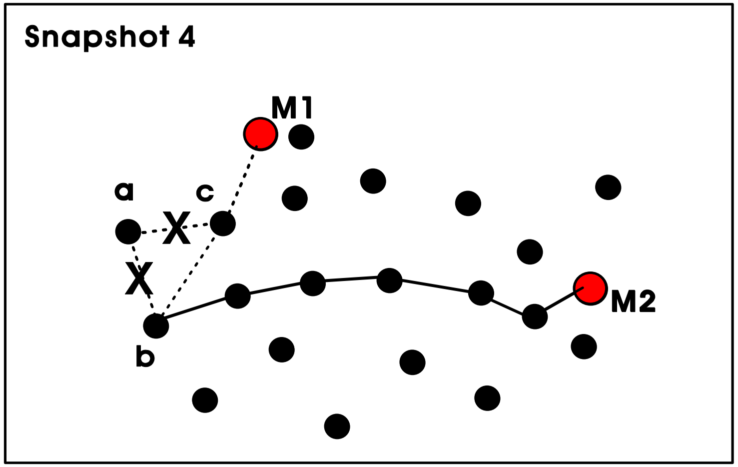
- Maintain Connectivity – Handoffs
- Local Optimization – “String Stretching”

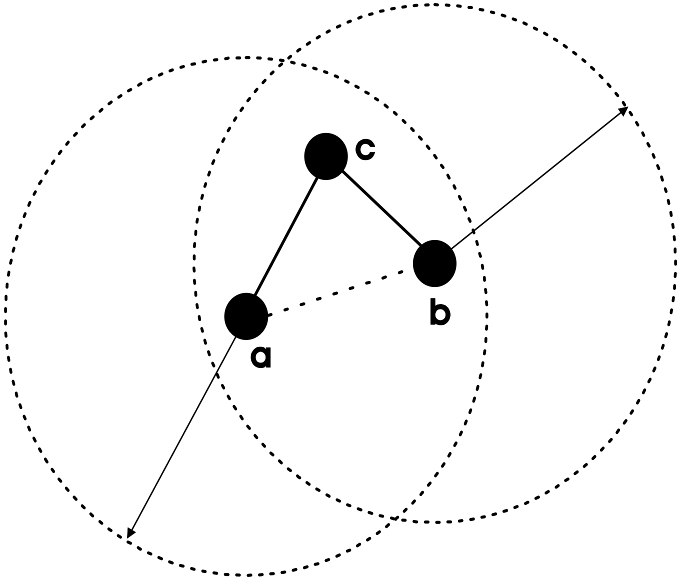
Path Maintenance



Local Optimizations







É - Compactness

$$\delta = \min_{u,v \in V} \frac{d(u,v)}{\hat{d}(u,v)}$$

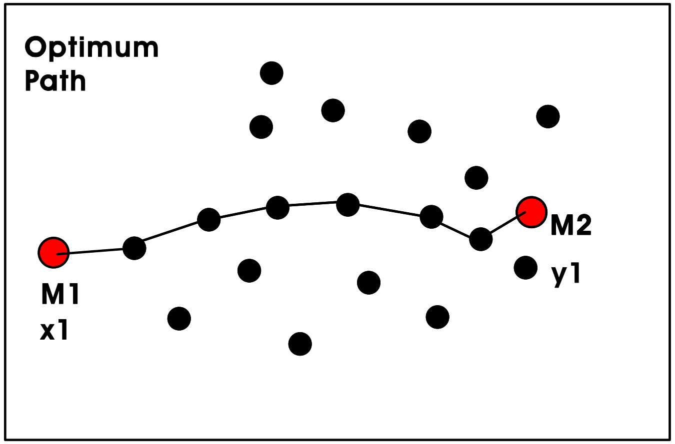
$d(u;v)$ *is the distance between nodes u and v*

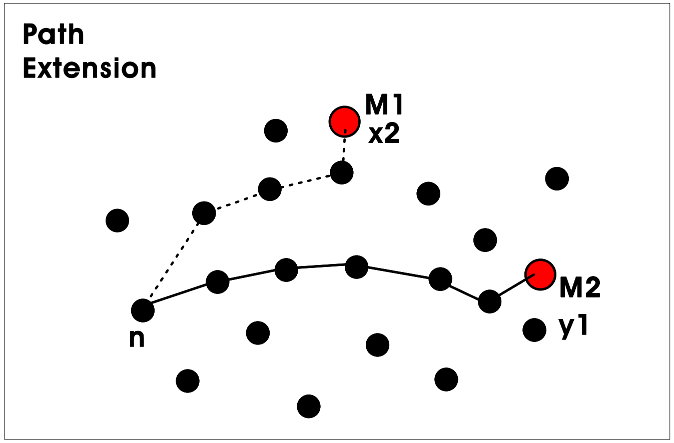
$\hat{d}(u;v)$ *is the network distance*

If a path of length ‘l’ is known between u and v, then the optimum path lies in the ellipse

$$E = \{x \in \mathbb{R}^2 \mid d(u,x) + d(x,v) \leq \min(l, \frac{1}{\delta} d(u,v))\}$$

Path sub-optimality





Path sub-optimality measures

$$\text{í} = \frac{|\text{à}|_{\text{ext}}}{|+|_{\text{ext}}}$$

measures change in topology since last search

$$\delta_{\text{ext}} = \min_{u,v \in P_{\text{ext}}} \frac{d(u,v)}{\hat{d}(u,v)}$$

measures compactness of the path

Search Region

$$E = \{x \in \mathbb{R}^2 \mid d(u,x) + d(x,v) \le \min(l, \frac{1}{\delta} d(u,v))\}$$

$$l_{\text{search}} = \min(l, \frac{1}{\delta} d(u,v))$$

for $0 < \alpha \le 1$, let

$$E_\alpha = \{x \in \mathbb{R}^2 \mid d(u,x) + d(x,v) \le \alpha l_{\text{search}}\}$$

e close to 1 – high energy + high chance of finding better path

Choice of e

Search over an ellipse such that search energy (estimate) satisfies

$$\mathcal{E}_{\text{search}}(\alpha) \leq R\Delta t(\mathcal{E}(l) - \mathcal{E}(\alpha l_{\text{search}}))$$

Where ....

-R = rate of data communication

-Δt = time for which topology does not change

-E (l) = energy for communicating one bit over a path of length (l) (need to have an estimate)

Proposed Algorithm

At each time step t

- If an agent becomes disconnected, do local handoff to maintain connectivity
- Do local optimization using one hop information
- If γ is less than 0.90 (10% change since last path search), look for nodes on the path extension which give minimum value of compactness value.
  - For this pair of nodes, choose α by the criterion on previous slid
  - Update path between this pair
  - update path between the agents

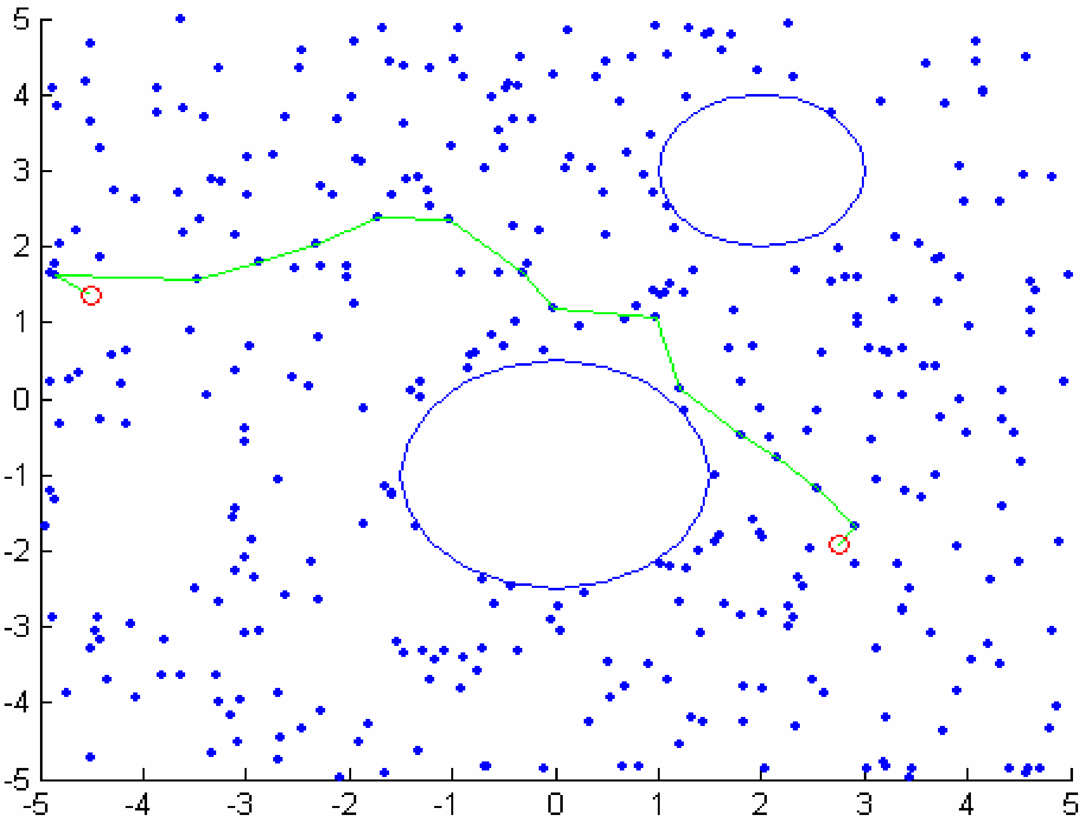
Simulation Study

- Objectives
  - Gain intuition
  - Compare the performance of various schemes
  - Derive a set of design parameters

Simulation Setups

- Setup A: uniform node density in a 10x10 field
- Setup B: uniform node density except for two holes.

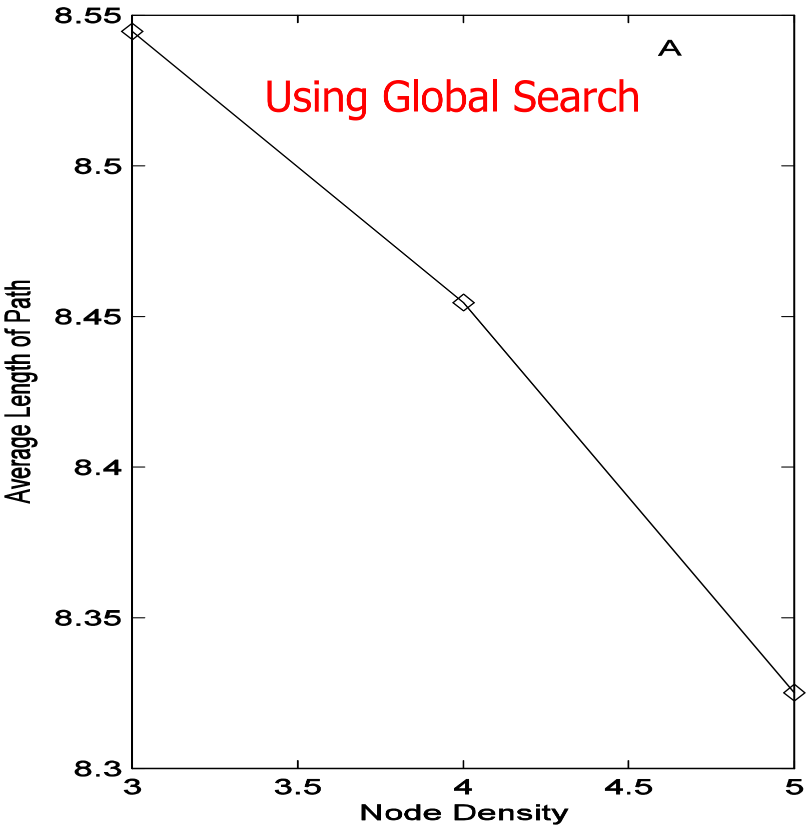
Setup B

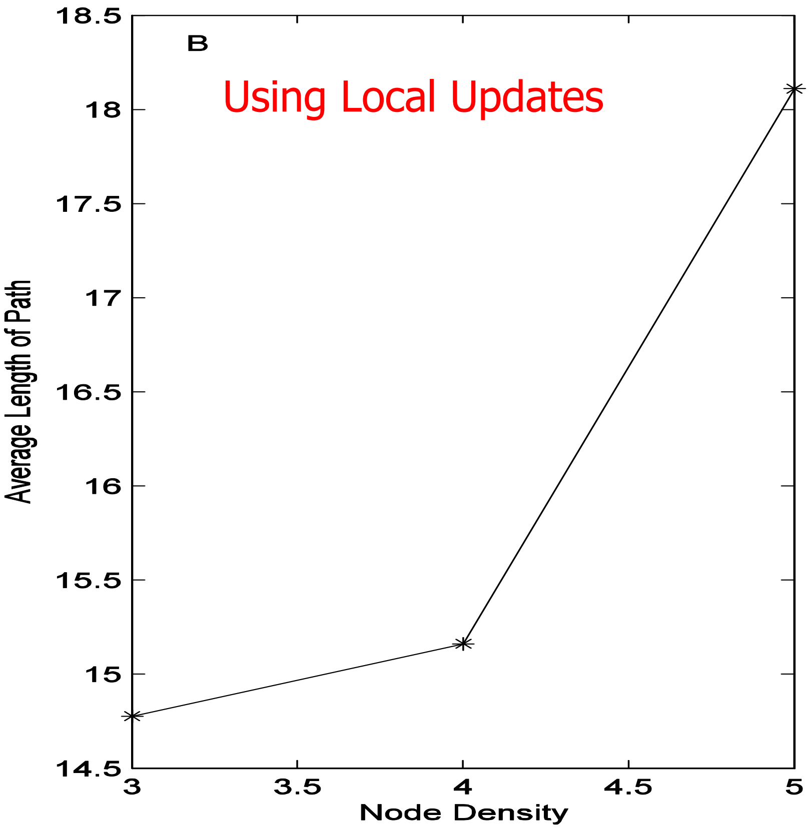


Experiment 1

- Does the average length of path maintained by an algorithm vary with node density?

Average Path Length





Experiment 2

- Objective
  - Compare the performance of different path update algorithms for a given scenario

Algorithms

When to Search?

Algorithm 1: Local Updates only

Algorithm 2: Uses only path compactness heuristic

Algorithm 3: Uses only % change in path length

Algorithm 4: Uses 2 and 3.

Results (Setup A)

Algorithm	**Average Length of Path**	**Number of Searches**	**Number of Nodes Searched**
Algo 1	16.95	0	0
Algo 2	8.4135	109	21238
Algo 3	7.9867	365	36181
Algo 4	8.4105	104	29909

Setup A. Agents moved around randomly for 10000 hops

Results (Setup B)

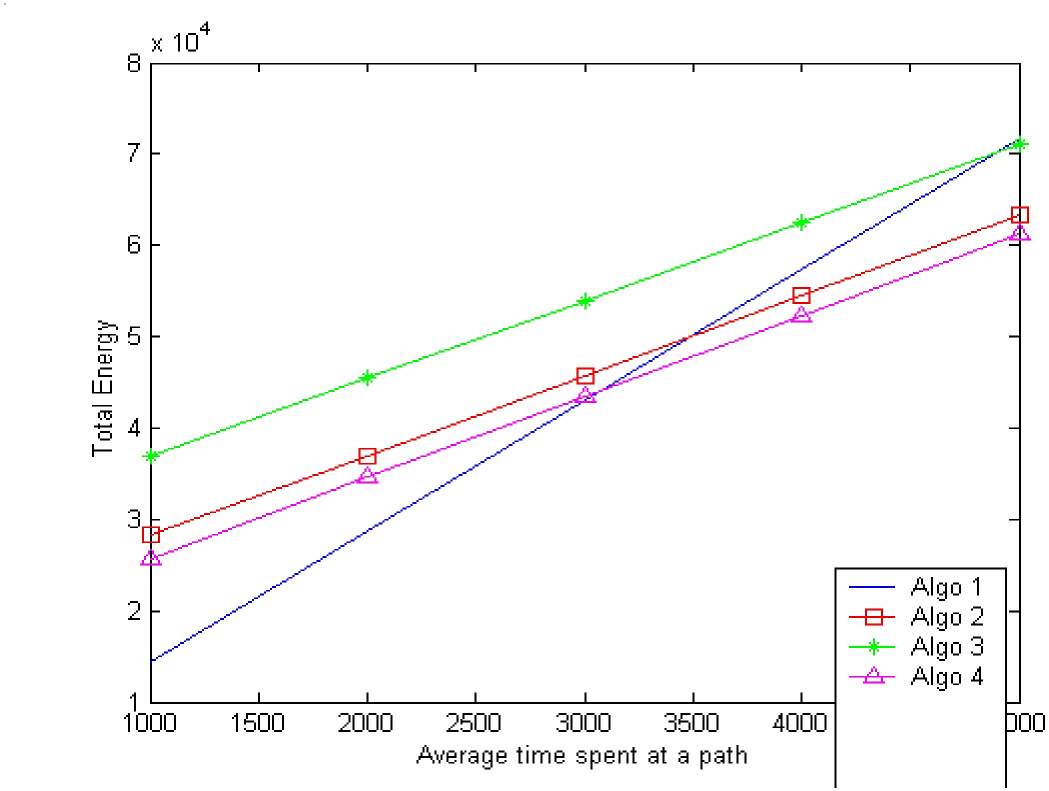
Algorithm	Average Length of Path	Number of Searches	Number of Nodes Searched
Algo 1	14.33	0	0
Algo 2	8.77	106	19454
Algo 3	8.52	291	28433
Algo 4	8.882	89	16826

Setup B. Agents moved around randomly for 10000 hops

Sample Energy Calculation

- E = C(L) * T + C(S)
  - C(L) - Average cost of transmitting on path of length L
  - T - Average time spent at a path
  - C(S) – Average Cost of search

Energy Budget



Calculations done for simulation results on setup B

In Conclusion…

- We proposed and studied different algorithms for path maintenance and update.
- Performance of the algorithms depend on the scenario at hand.
- More simulations studies are required to characterize different environments and to derive design parameters.