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Study and Research Project on paper

Mobility Models for UAV Group Reconnaissance Applications

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Master 2 Computer Science, Networks, Systems and Mobility

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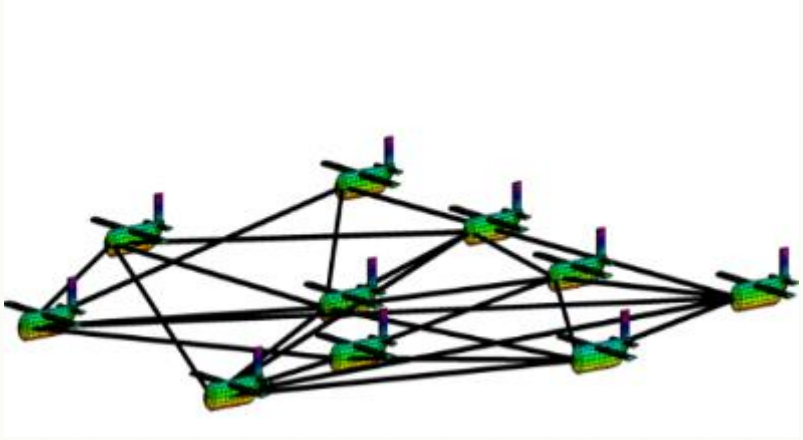
Outline

- Domain
- Article
- Our implementation
- Conclusion

Context

- UAV
- Swarm of UAVs
- Mobility models



Source : « http://rain.aa.washington.edu »

➔ How do they move ?

Source : "http://www.swiss-uav.com "

Problematics

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How to scan an area properly ?

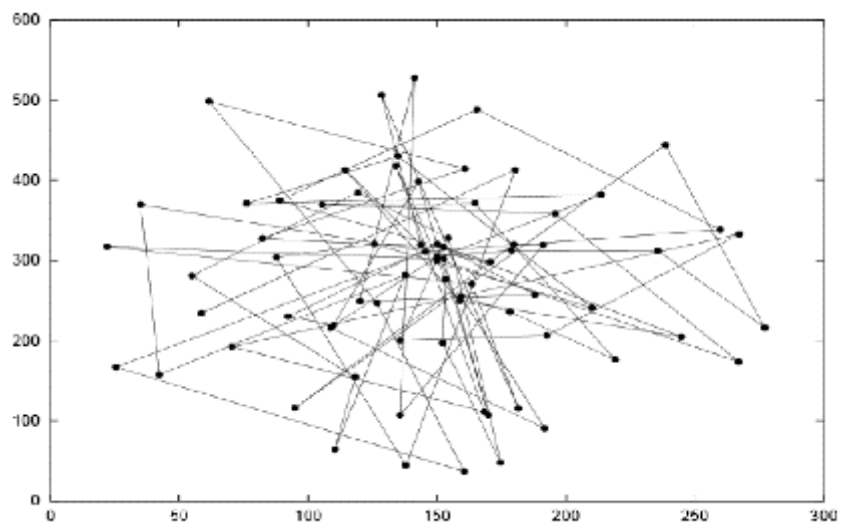
As much and as quickly possible, in a limited time and at least, once every hour

Source : " http://technorati.com "

Study of existing models

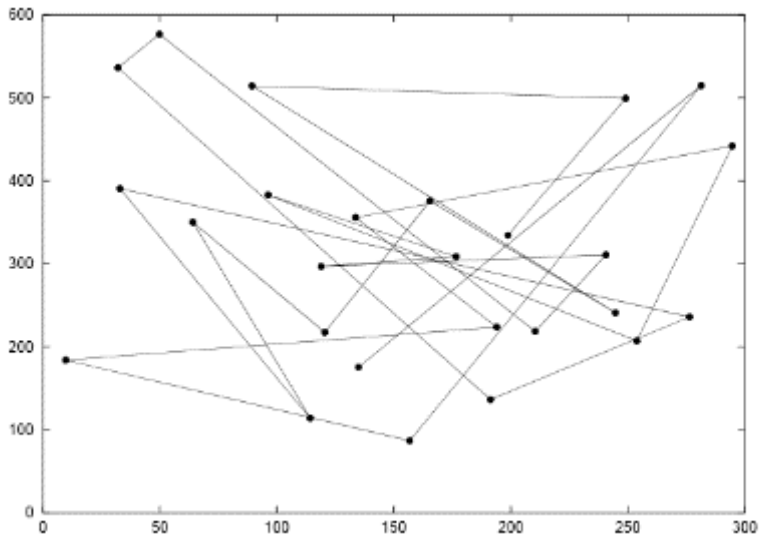
Existing Models

- Random Walk



Result pattern of random walk [2]

- Random WayPoint



Result pattern of random waypoint [2]

Study of existing models

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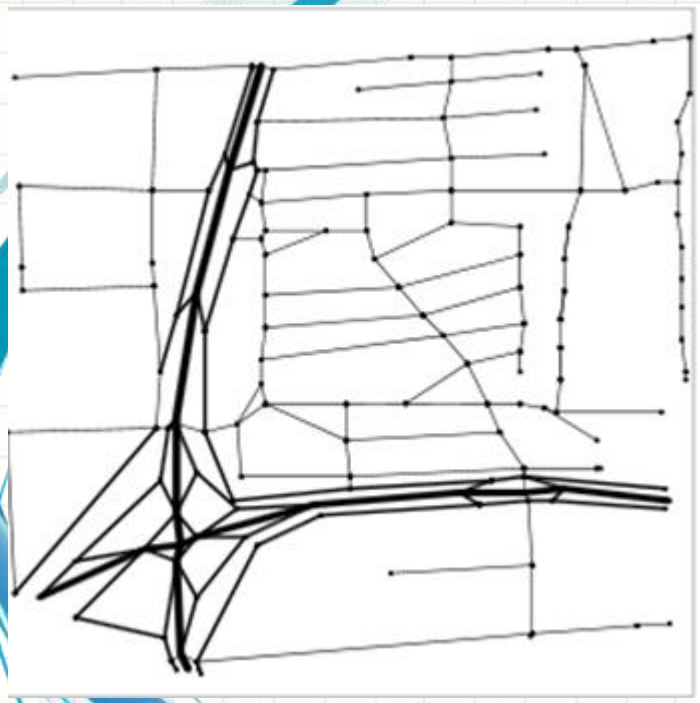
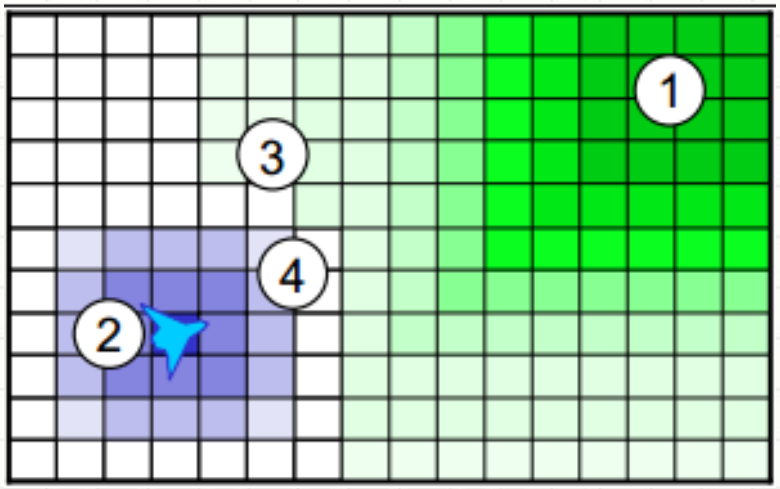
- City Section



Street scenario corresponding to a square area size 1900x1900 [3]

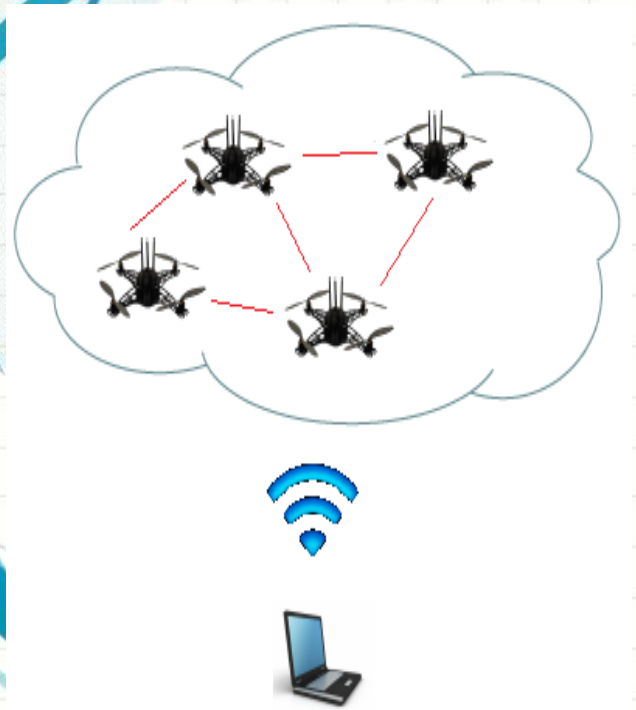
- Distributed Pheromone



Attractive and repulsive pheromones for surveillance [4]

Blue : repulsive
Green : attractive

About the article



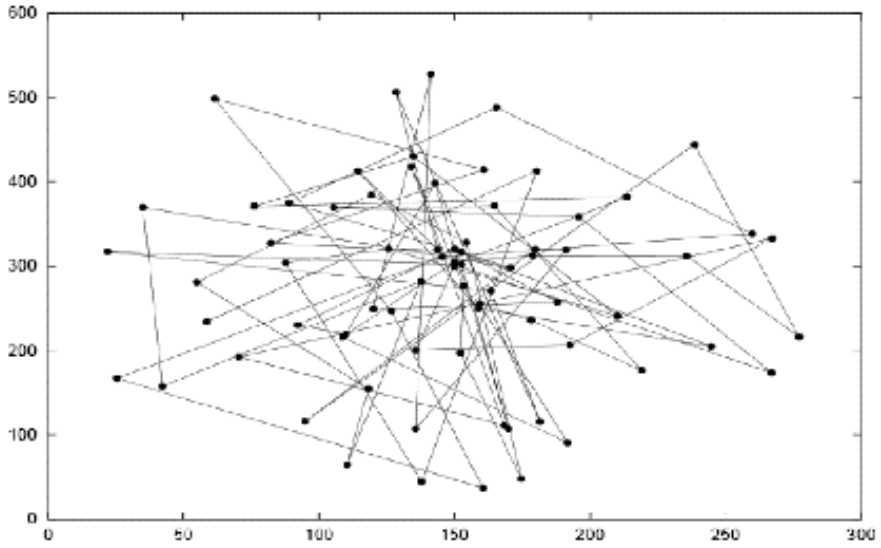
Introduction

- MANET
  - Mobile Ad Hoc Network
  - Networks of mobile entities
  - Collect, process and transmit data
- UAV
  - Application of mobility models with UAVs
- 2 different mobility models
  - Random Walk
  - Distributed Pheromone Repel

Models studied in the article

Random Walk model

- Each drone is independent
- No backup position
- Random target



Result pattern of random walk [2]

Models studied in the article

Random Walk model

	Probability of action		
Last action	**Turn left**	**Straight ahead**	**Turn right**
Straight ahead	10%	80%	10%
Turn left	70%	30%	0%
Turn right	0%	30%	70%

UAV random action table [2]

Models studied in the article

Distributed Pheromone Repel model

- Coordination of UAVs thanks to pheromones
- Adaptative UAV

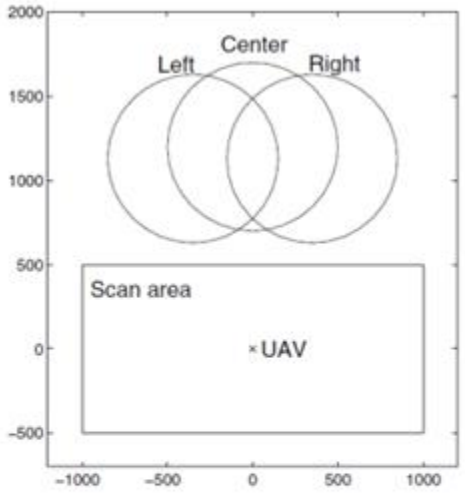
Models studied in the article

Distributed Pheromone Repel model

- One pheromone map per UAV
- Marks the areas when they have been scanned
- Regularly broadcast a local area pheromone map (when a distance is inferior to 8 km between two UAVs)

Models studied in the article

Distributed Pheromone Repel model



Pheromone search pattern [1]

Probability of action		
Turn left	**Straight ahead**	**Turn right**
(Total – Left) / (2 * Total)	(Total – Center) / (2 * Total)	(Total – Right) / (2 * Total)

UAV pheromone action table [1]

Experiments

Scenarios for the 2 models

- Characteristics
  - Square with a side length of 30 Km
  - 10 UAVs per run
  - Fixed wing aircraft

- Requirements
  - Data must be returned to the C&C [1]
  - No excessive use of bandwidth (no quantification in the article)

1 : Command and Controler center

Experiments

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Expected results :

Scan the area in 40 min

Obtained results :

Mobilities Models	RandomWalk	Pheromone
Time to scan the area	80% of the area in 120 min	90% of the area in 50 min
Connectivity	Low	Low

Experiments

Our point of view about limitations

- Speed and shift (direction)
- Coverage and connectivity of communications are two conflicting objectives
- Comparison between pheromone and random model is not adapted
- Communication between UAVs are unrealistic

Comparison of 2 models

Scan characteristic

Both models manage quite well to avoid rescanning a recently scanned area

	Max	Median	Min
Random	16.2%	3.2%	0.5%
Pheromone	0.21%	0.03%	0.01%

Never scanned area [1]

Our Implementation

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All models

- Everything was done
- 10 nodes/models
- Rebound method
- Percentage of scan
- Tracking display

Pheromone model

- Communication between UAVs

Our Implementation

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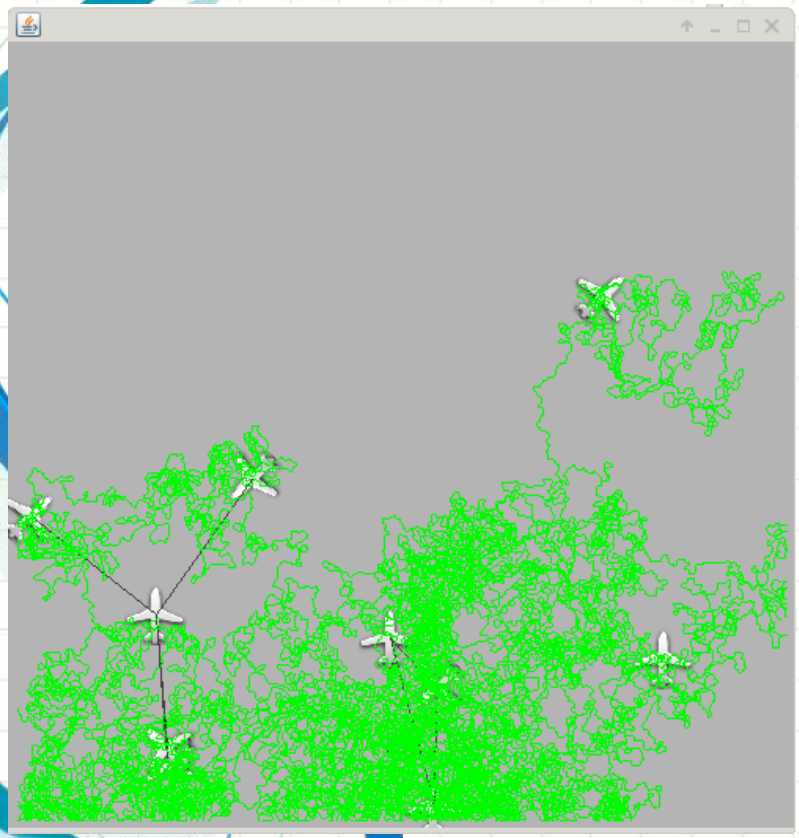
JBotSim view



Pheromone model

```
Main [Java Application] /usr/lib/jvm/jdk-7-oracle-x64/bin/
Scan : 16.2019991670137 46% during 2 min 0 sec
Scan : 16.2019991670137 46% during 2 min 0 sec
Scan : 16.2024156601416 07% during 2 min 0 sec
Scan : 16.2024156601416 07% during 2 min 0 sec
Scan : 16.2024156601416 07% during 2 min 0 sec
Scan : 16.2024156601416 07% during 2 min 0 sec
Scan : 16.2028321532694 7% during 2 min 0 sec
Scan : 16.2028321532694 7% during 2 min 0 sec
Scan : 16.2032486463973 34% during 2 min 0 sec
```

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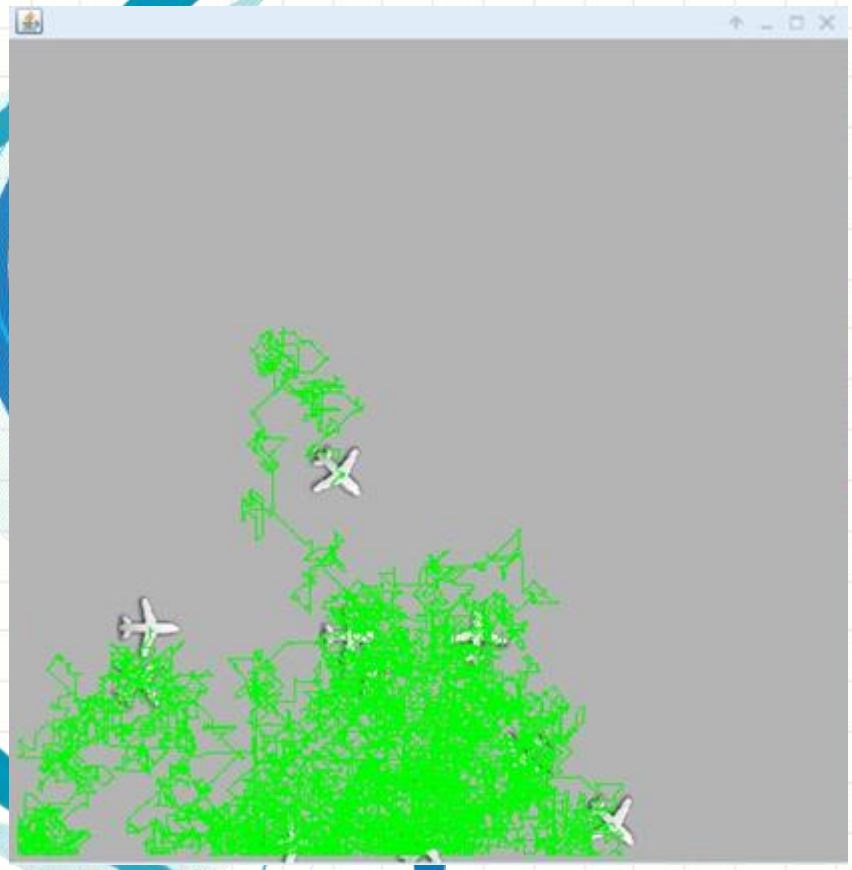
JBotSim view



Random Walk model

Problems @ Javadoc Declaration Consol

Main (2) [Java Application] /usr/lib/jvm/jdk-7-oracle-x64/t

```
Scan : 22.65264473136193% during 2 min 0 sec
Scan : 22.65264473136193% during 2 min 0 sec
Scan : 22.65264473136193% during 2 min 0 sec
Scan : 22.653061224489797% during 2 min 0 sec
Scan : 22.653061224489797% during 2 min 0 sec
Scan : 22.65347771761766% during 2 min 0 sec
Scan : 22.653894210745523% during 2 min 0 sec
Scan : 22.65431070387339% during 2 min 0 sec
Scan : 22.65431070387339% during 2 min 0 sec
Scan : 22.65431070387339% during 2 min 0 sec
Scan : 22.654727197001247% during 2 min 0 sec
Scan : 22.655143690129112% during 2 min 0 sec
Scan : 22.655143690129112% during 2 min 0 sec
Scan : 22.655143690129112% during 2 min 0 sec
Scan : 22.655143690129112% during 2 min 0 sec
Scan : 22.655143690129112% during 2 min 0 sec
Scan : 22.655143690129112% during 2 min 0 sec
Scan : 22.655560183256977% during 2 min 0 sec
```

Our Implementation

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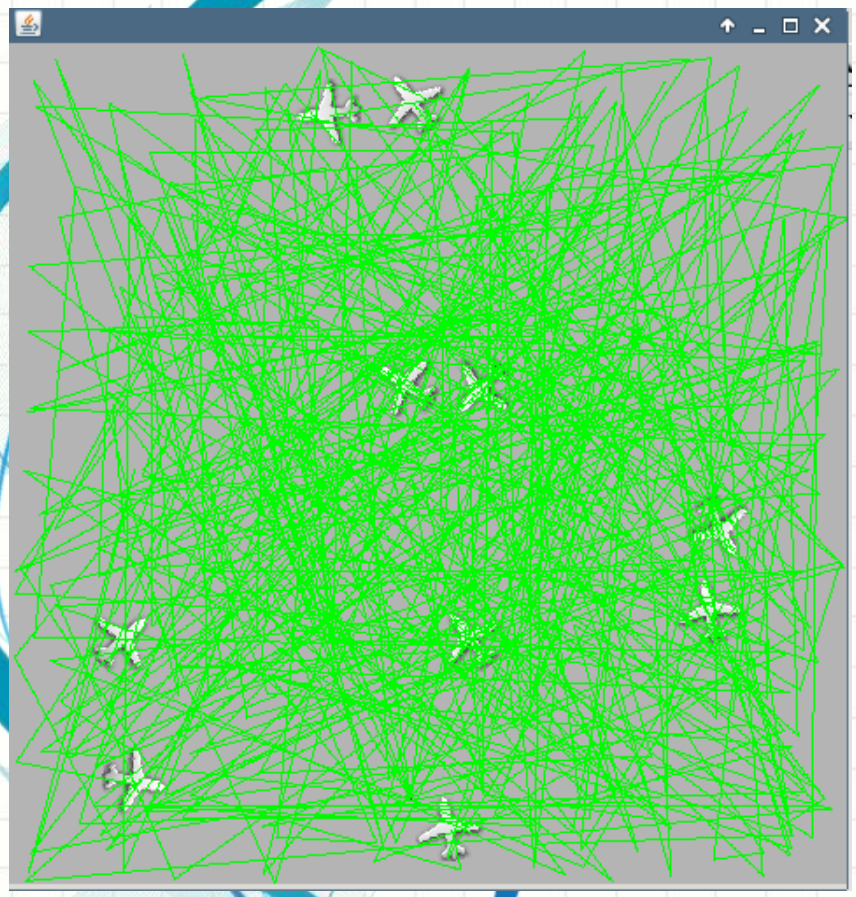
JBotSim view



Random Waypoint model

Problems @ Javadoc Declaration Consol

Main (1) [Java Application] /usr/lib/jvm/jdk-7-oracle-x64/b

```
Scan : 35.723958333333336% during 2 min 0 sec
Scan : 35.724392361111114% during 2 min 0 sec
Scan : 35.724826388888886% during 2 min 0 sec
Scan : 35.725260416666664% during 2 min 0 sec
Scan : 35.725260416666664% during 2 min 0 sec
Scan : 35.72569444444444% during 2 min 0 sec
Scan : 35.72569444444444% during 2 min 0 sec
Scan : 35.72569444444444% during 2 min 0 sec
Scan : 35.72569444444444% during 2 min 0 sec
Scan : 35.72612847222222% during 2 min 0 sec
Scan : 35.72612847222222% during 2 min 0 sec
Scan : 35.7265625% during 2 min 0 sec
Scan : 35.72699652777778% during 2 min 0 sec
Scan : 35.72743055555556% during 2 min 0 sec
Scan : 35.72743055555556% during 2 min 0 sec
Scan : 35.727864583333336% during 2 min 0 sec
Scan : 35.727864583333336% during 2 min 0 sec
```

Our Implementation

Interpretation of results

- At the beginning, the Random models are more efficients
- At the end, random models are stable
- Pheromone model is more effective than the others models to reach 100% of scan

Our Implementation

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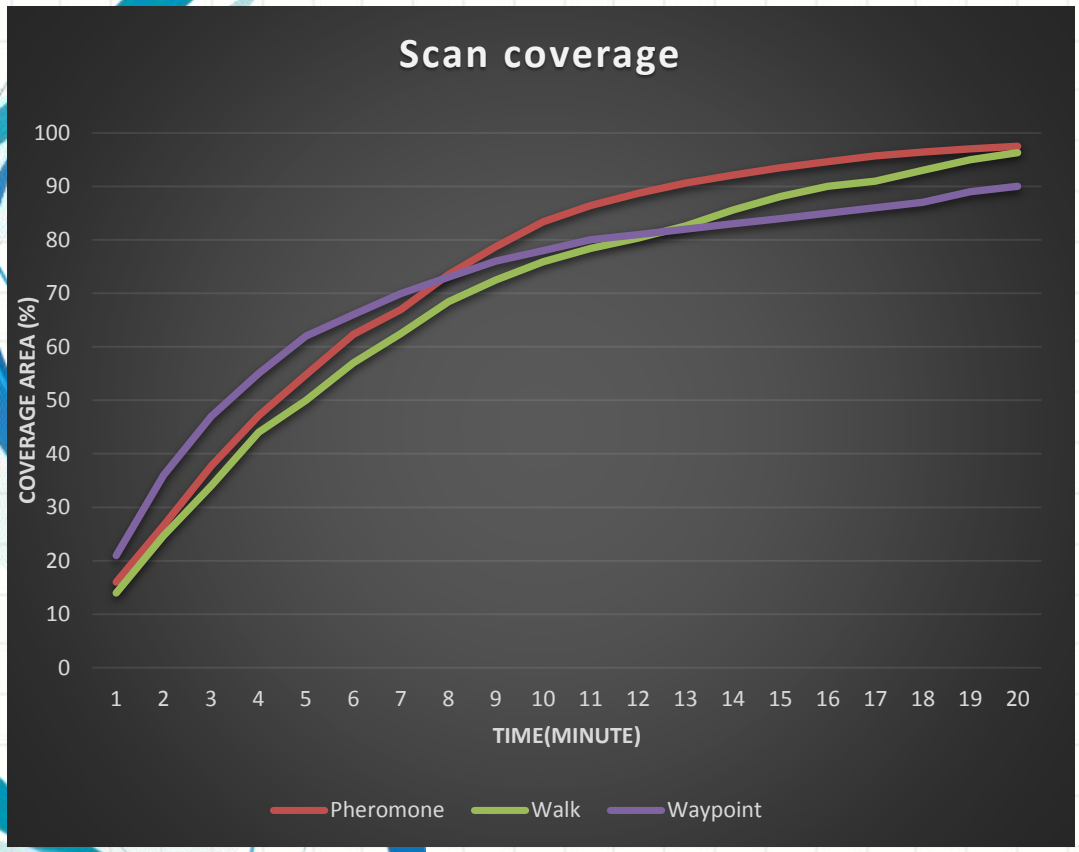
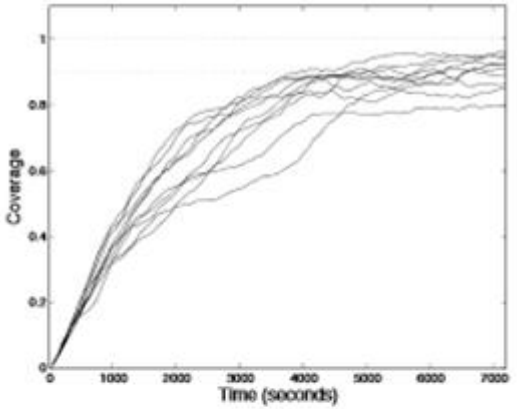
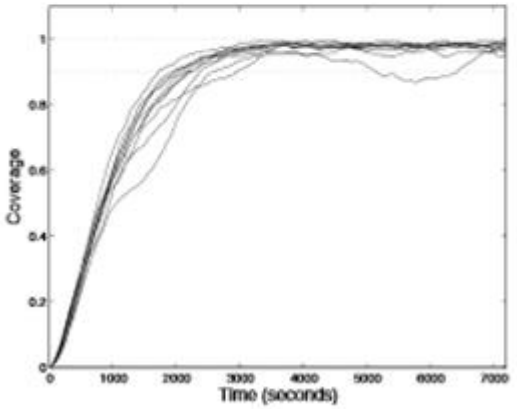
Comparison with article





Random mobility coverage [1]



Pheromone mobility coverage [1]

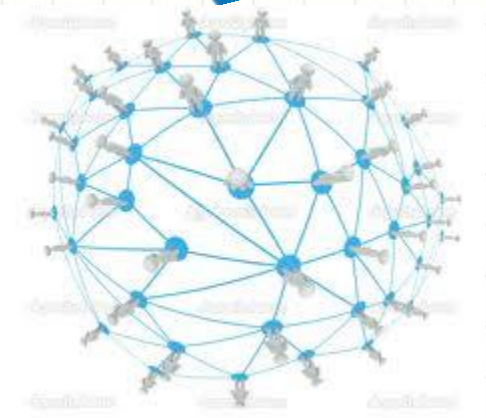
Our Implementation

Importance of the Mobility Model choosen

Mobility Model / Scenarios	Semi-Random-Circular-Movement	Distributed Pheromone Repel	Smooth turn
Scan Coverage	✓	✓	
Airborne Networks			✓

Conclusion

- Good model for scan coverage and reconnaissance scenario
- Characteristics of evaluation and experiments are unrealistic
- Possible improvement is to store and forward data and relax the limited bandwidth



Source : " http://fr.depositphotos.com "

Source : " http://www.vikingaero.com "

Source : " http://titanaerospace.com "

DO YOU HAVE ANY QUESTIONS ?

References

- E. Kuiper and S. Nadjm-Tehrani.

[1] *Mobility models for uav group reconnaissance applications. In Wireless and Mobile Communications, 2006. ICWMC '06. International Conference on, page 33, July 2006.*

"http://dept-info.labri.fr/~desbarat/PER/sujets/Autefage1-article.pdf "

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[4] J. A. Sauter, R. Matthews, H. V. D. Parunak, S. A.Brueckner. Performance of Digital Pheromones for Swarming Vehicle Control. Fourth International Joint Conference on Autonomous Agents and Multi-Agent Systems. July, 2005. ACM Press