Study and Research Project on paper

MOBILITY MODELS FOR UAV GROUP RECONNAISSANCE APPLICATIONS

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Outline

- Domain
- Article
- Our implementation
- Conclusion

Context

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

- UAV

- Swarm of UAVs

- Mobility models
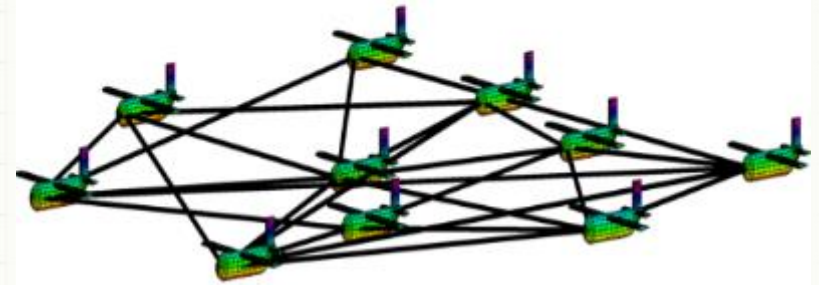
➔ How do they move ?

Problematics

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

How to scan an area properly ?

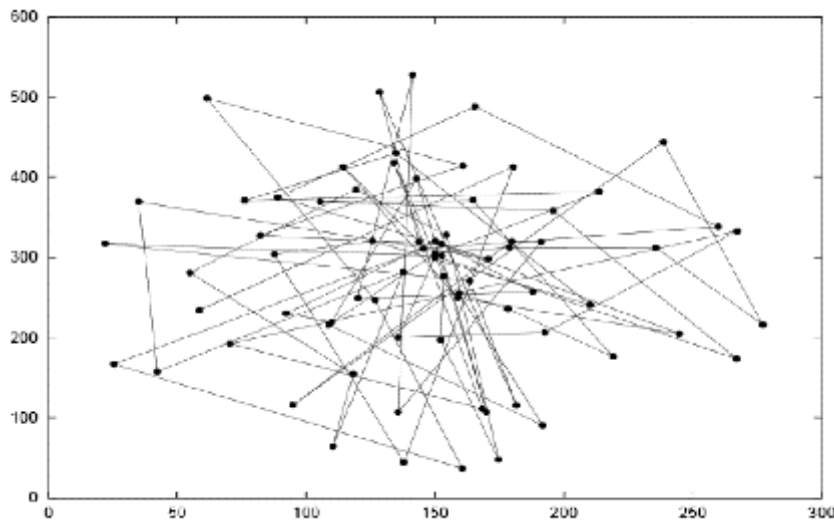*As much and as quickly possible, in a limited time and at least, once every hour*

Source : " http://technorati.com "

Study of existing models

Existing Models

- ### Random Walk
- ### Random WayPoint

Result pattern of random walk [2]
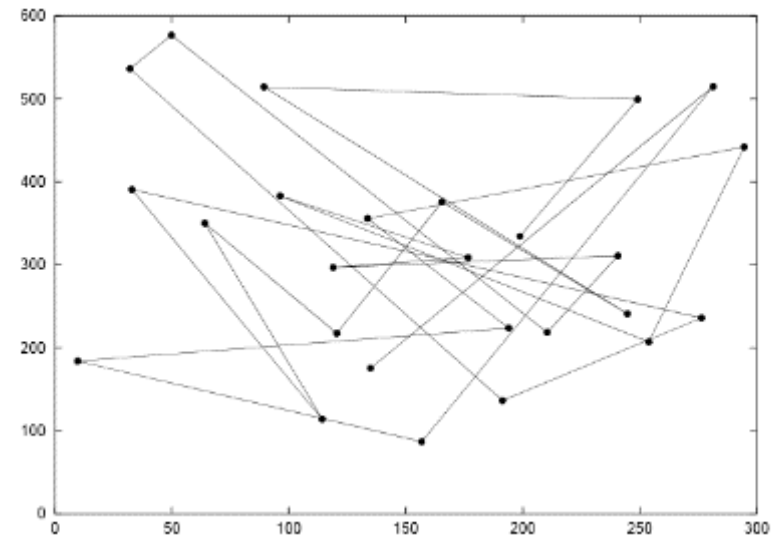
Result pattern of random waypoint [2]

Study of existing models

- City Section
- Distributed Pheromone
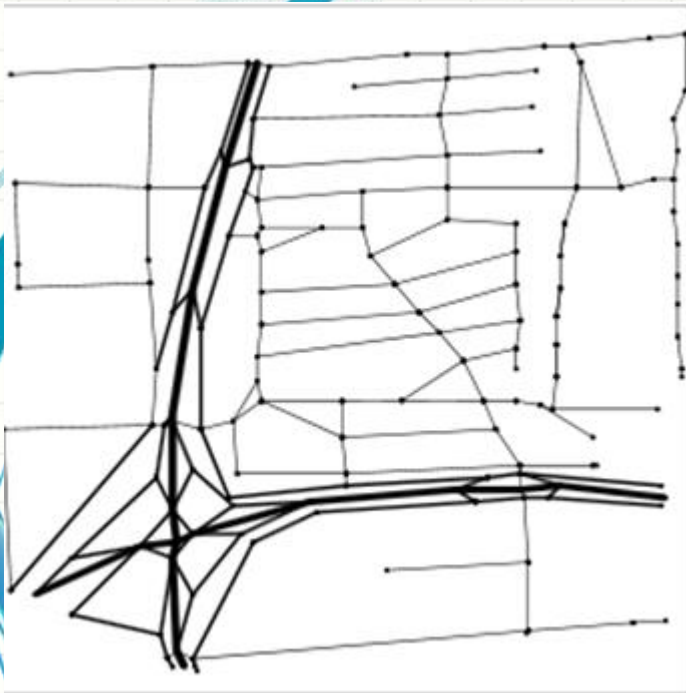
Street scenario corresponding to a square area size 1900x1900 [3]
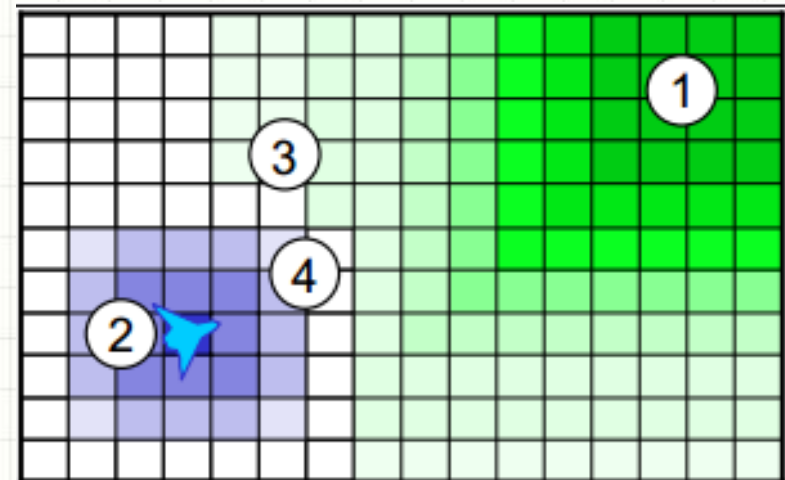
Attractive and repulsive pheromones for surveillance [4]

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
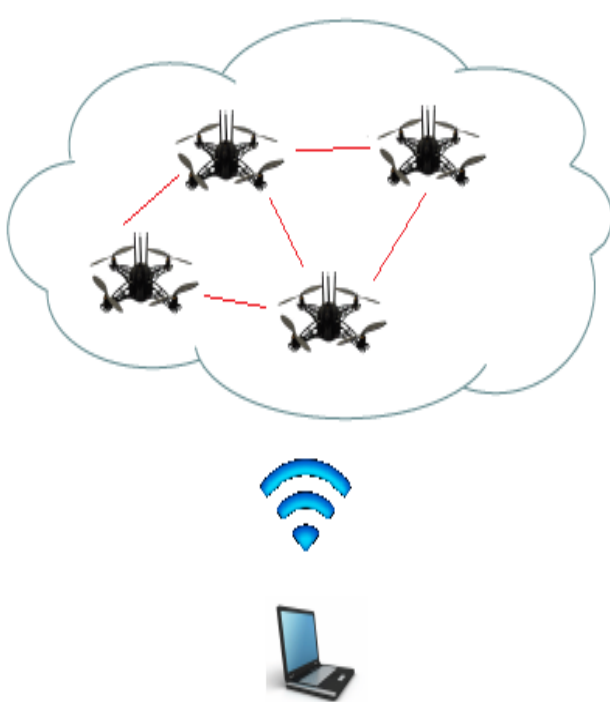
Models studied in the article

Random Walk model

- Each drone is independent

- No backup position

- Random target
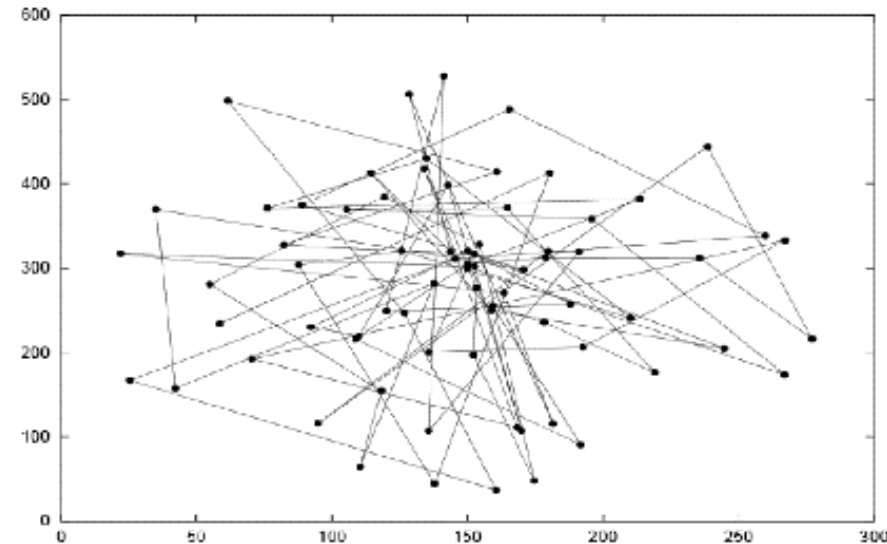
Result pattern of random walk [2]

Models studied in the article

Random Walk model

Last action	Probability of 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

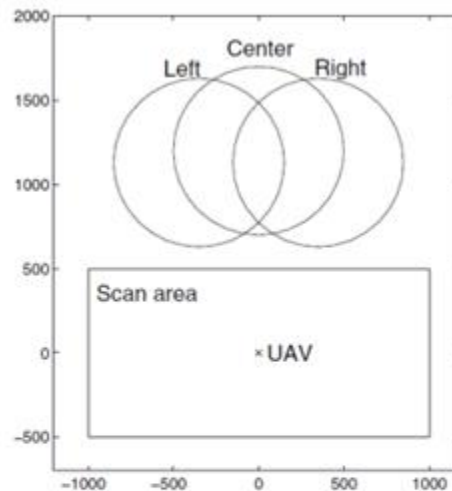# Models studied in the article

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

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

1 : Command and Controler center

Experiments

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

All models

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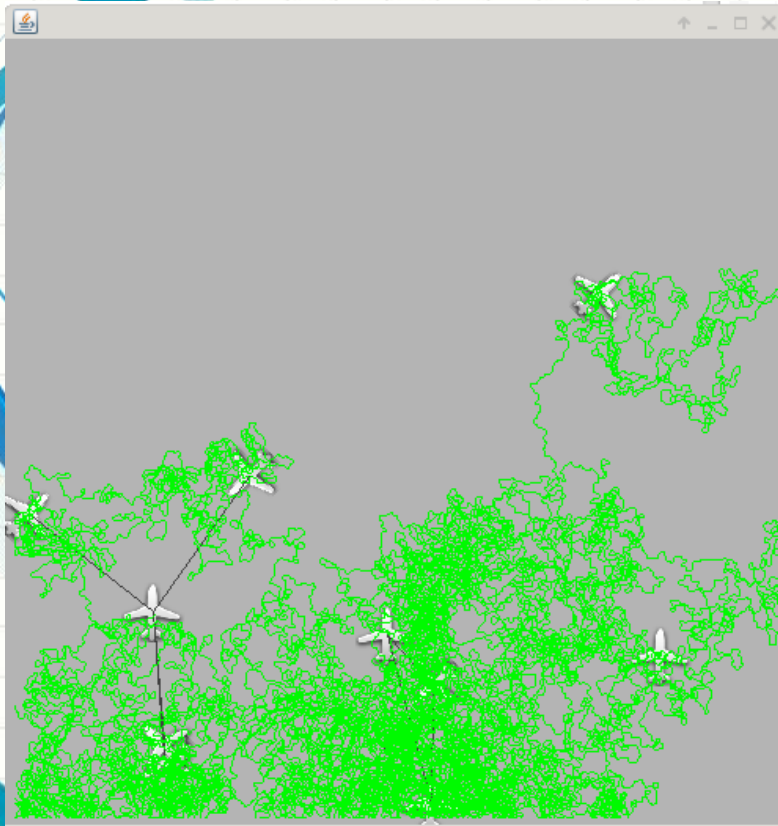- Percentage of scan
- Tracking display

Pheromone model

- Communication between UAVs

Our Implementation

JBotSim view

Pheromone model


```
Main [Java Application] /usr/lib/jvm/jdk-7-oracle-x64/bin/
Scan : 16.201999167013746% during 2 min 0 sec
Scan : 16.201999167013746% during 2 min 0 sec
Scan : 16.202415660141607% during 2 min 0 sec
Scan : 16.202415660141607% during 2 min 0 sec
Scan : 16.202415660141607% during 2 min 0 sec
Scan : 16.202415660141607% during 2 min 0 sec
Scan : 16.20283215326947% during 2 min 0 sec
Scan : 16.20283215326947% during 2 min 0 sec
Scan : 16.203248646397334% during 2 min 0 sec
```

Our Implementation

Domain
Article
Implementation
Conclusion

JBotSim view

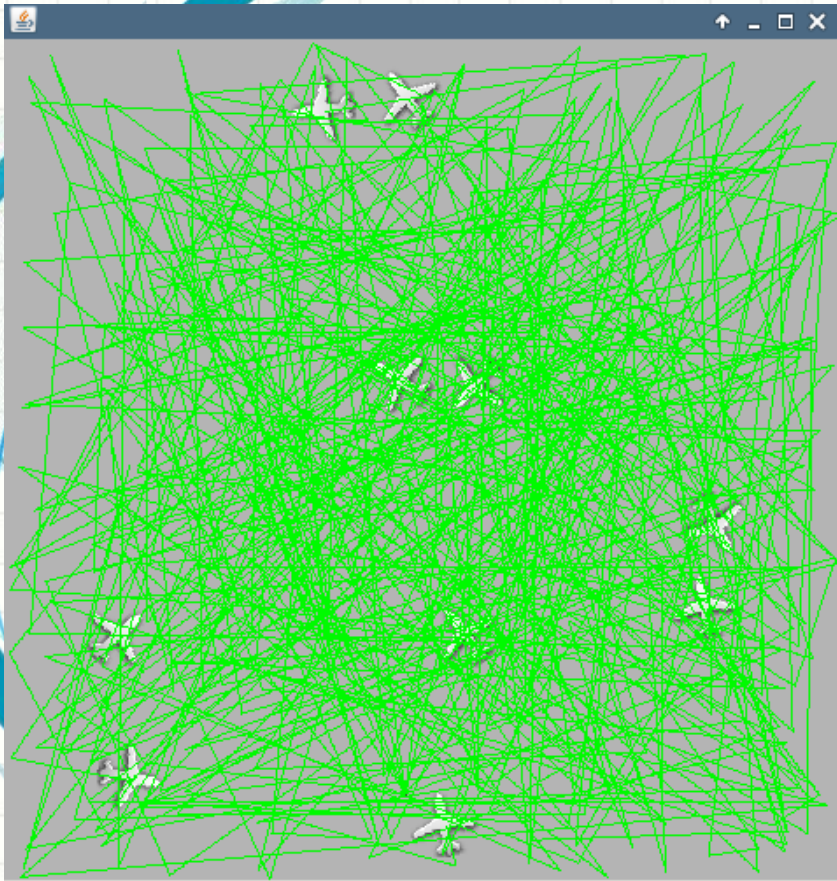## Random Walk model
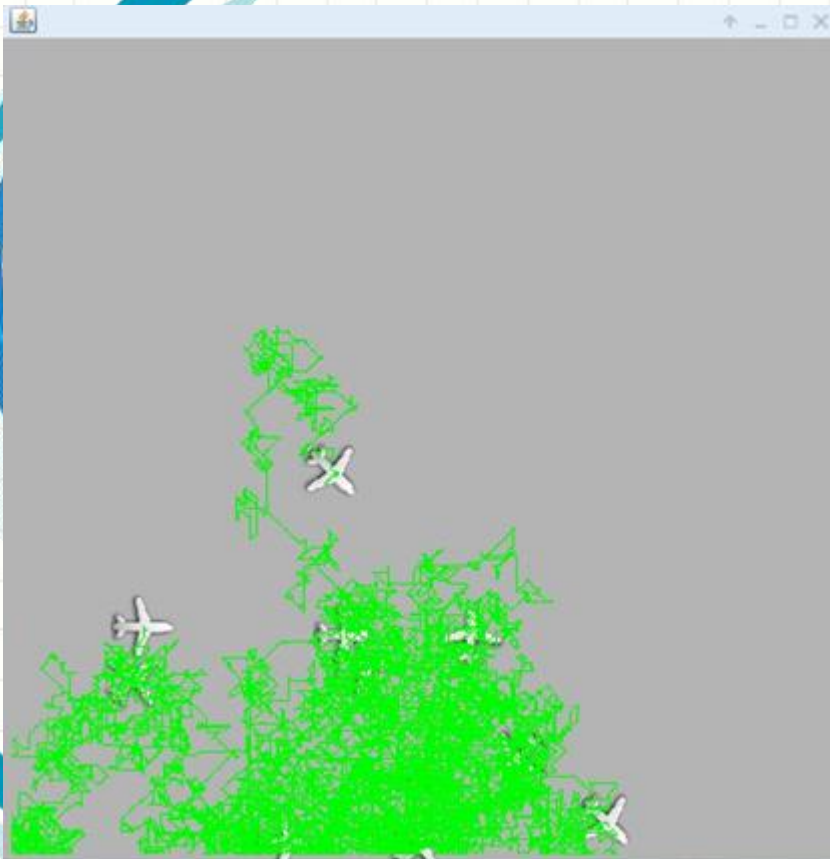
Problems @ Javadoc Declaration Console

Main (2) [Java Application] /usr/lib/jvm/jdk-7-oracle-x64/b
Scan : 22.652644731136193% during 2 min 0 sec
Scan : 22.652644731136193% during 2 min 0 sec
Scan : 22.652644731136193% during 2 min 0 sec
Scan : 22.653061224489797% during 2 min 0 sec
Scan : 22.653061224489797% during 2 min 0 sec
Scan : 22.653477771761766% during 2 min 0 sec
Scan : 22.653894210745523% during 2 min 0 sec
Scan : 22.654310703873339% during 2 min 0 sec
Scan : 22.654310703873339% during 2 min 0 sec
Scan : 22.654310703873339% 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

JBotSim view

Random Waypoint model


```
Problems  @ Javadoc  Declaration  Consol
Main (1) [Java Application] /usr/lib/jvm/jdk-7-oracle-x64/b
Scan : 35.7239583333333336% during 2 min 0 sec
Scan : 35.7243392361111114% during 2 min 0 sec
Scan : 35.7248263888888886% during 2 min 0 sec
Scan : 35.7252604166666664% during 2 min 0 sec
Scan : 35.7252604166666664% 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
```
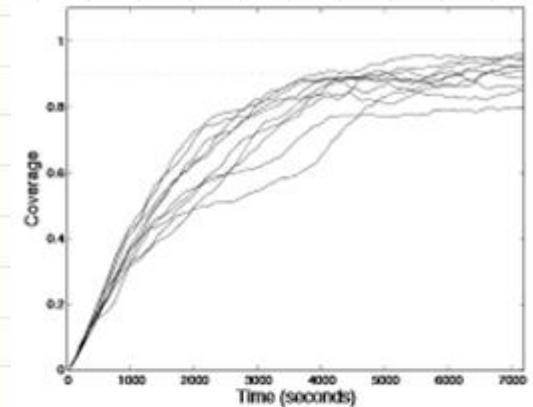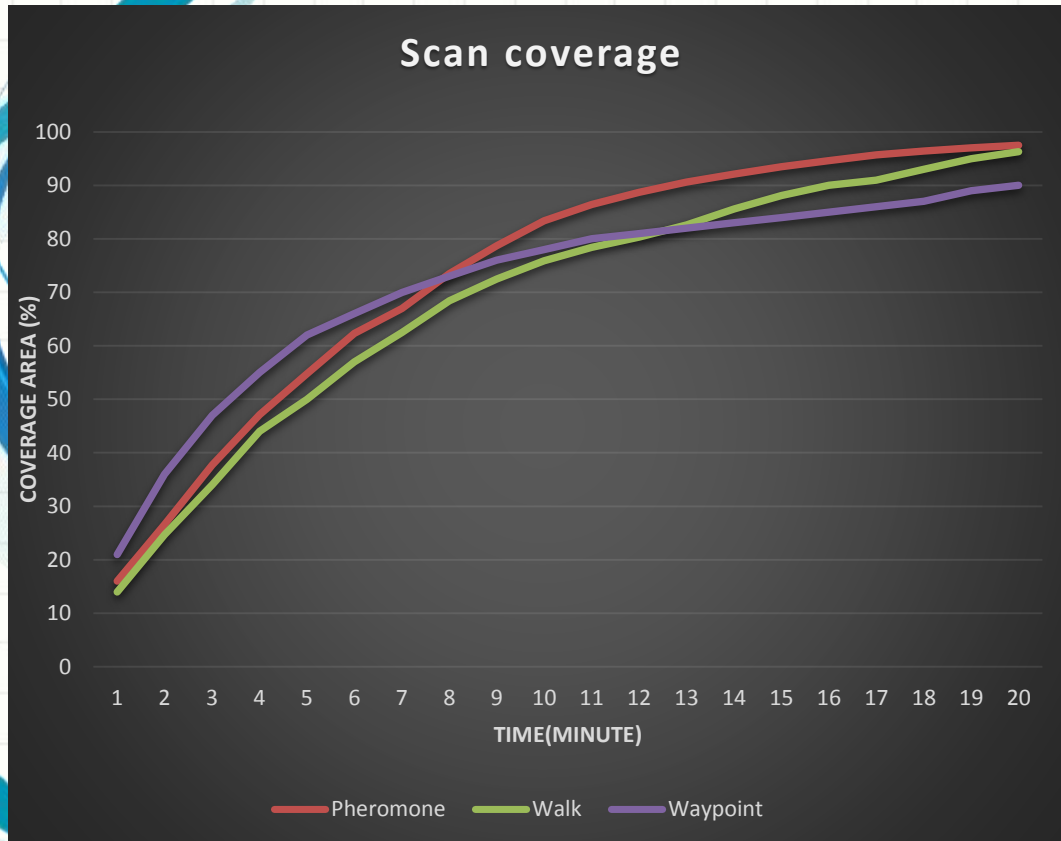
Our Implementation

Interpretation of results

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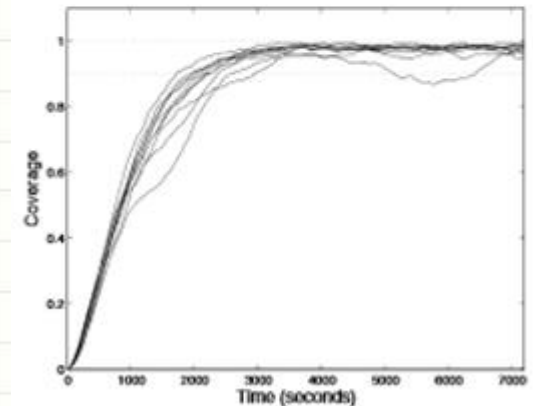- Pheromone model is more effective than the others models to reach 100% of scan

Our Implementation

Comparison with article

Scan coverage

Random mobility coverage [1]

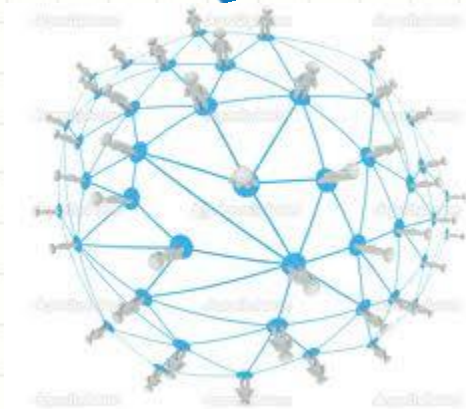Pheromone mobility coverage [1]

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://www.vikingaero.com "

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

[2] : A. Jardosh, E. M. Belding-Royer, K. C. Almeroth, S. Suri. Towards Realistic Mobility Models for Mobile Ad Hoc Networks. 9th annual International Conference on Mobile Computing and Networking. September 2003. ACM Press

[3] A. K. Saha, D. B. Johnson. Modeling Mobility for Vehicular Ad Hoc Networks. First ACM Workshop on Vehicular Ad Hoc Networks. October 2004. ACM Press

[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