University of Bordeaux 1 - Science and Technology

Mobility Models for UAV Group Reconnaissance Applications

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IEEE lecture 2006

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Master 2 Computer Science **Study and Research Project** **2013-2014**

Plan

- Context
- Problematic
- Study of existing
- Our article
- Models of our study
- Experiments
- Comparison of 2 models
- Our Implementation
- Conclusion

Context

- UAV
- Swarm of UAVs
- Mobility models

➔ How do they move ?

Problematic

Figure 1 . Source : "http://www.swiss-uav.com "

How well scan an area ?

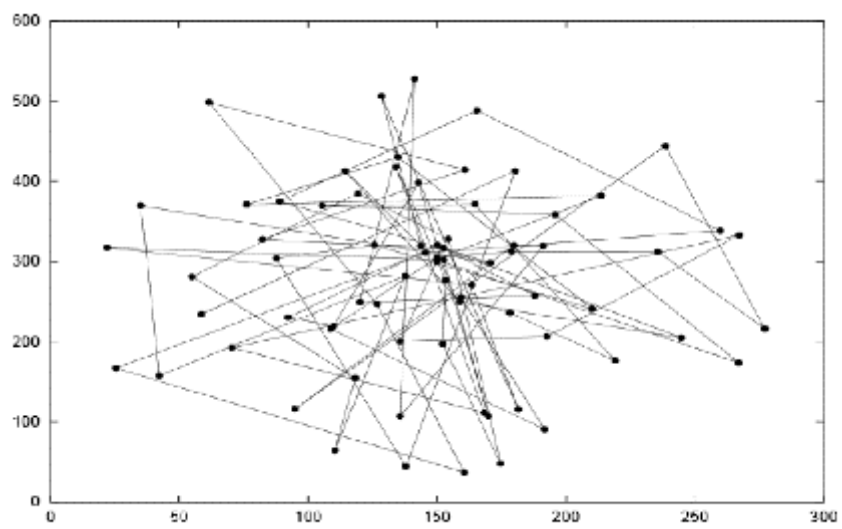
As much and as quickly possible, in a limited time and at least, once every hour.

Figure 2. Source : " http://technorati.com "

Study of existing

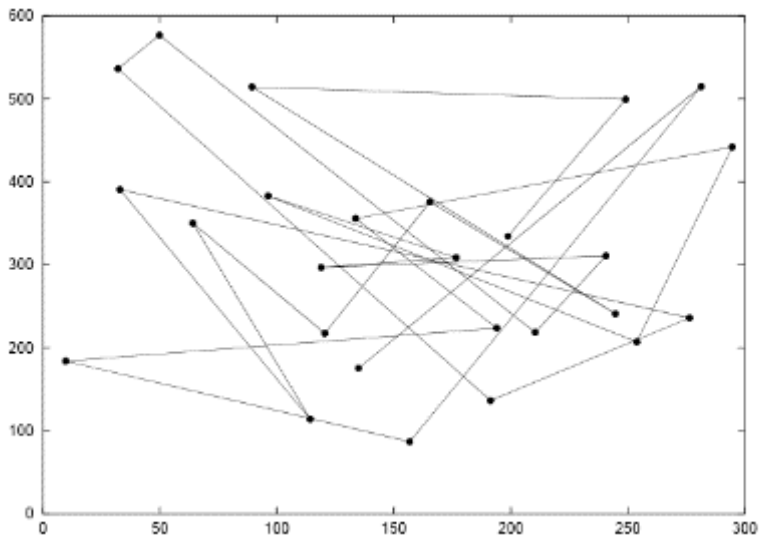
Existing Models

- Random Walk



[1] : Result pattern of Random Walk

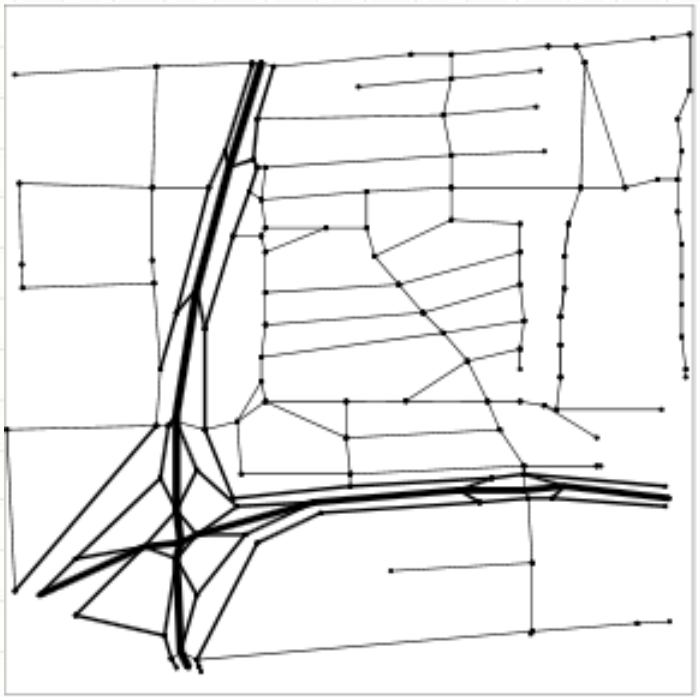
- Random WayPoint



[2] : Result pattern of Random Walk

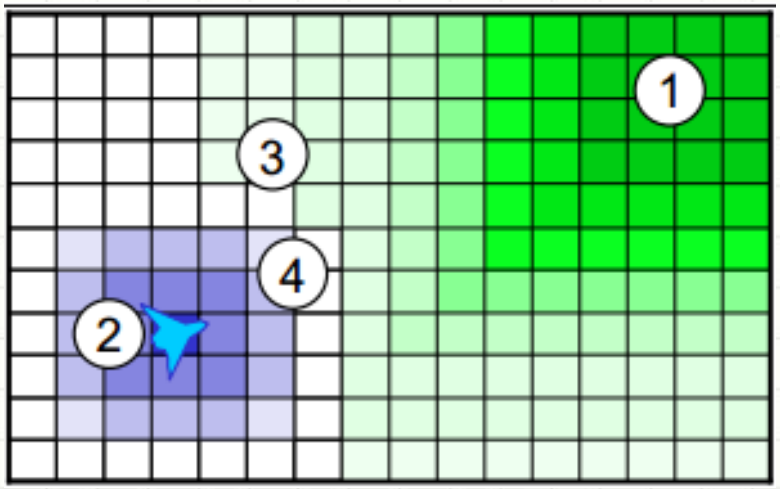
Study of existing

- City Section



[3] : **(b) Region *B***: Street scenario corresponding to a square area of size 1900 m×1900 m

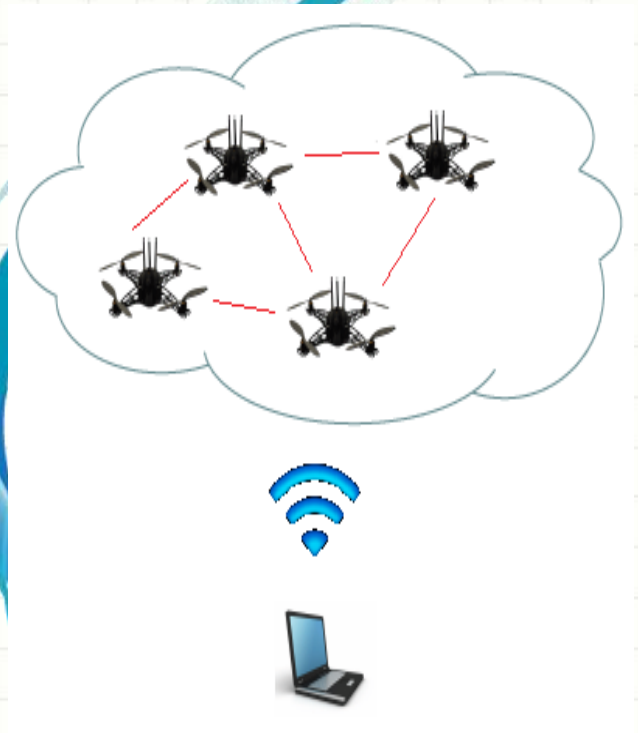
- Distributed Pheromone Repel



[4] : Attractive and Repulsive Pheromones For Surveillance

Blue : repulsive
Green : attractive

Our Article



Introduction

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

Models of our study

Random Waypoint model

- Each drones are independant
- No backup position
- Random target

Models of our study

Random Waypoint model

Table 1. UAV random action table.

	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%

From : "*Mobility Models for UAV Group Reconnaissance Applications*"
By : *E. Kuiper and S. Nadjm-Tehrani.*

Models of our study

Distributed Pheromone Repel model

- Coordination of UAVs thanks to pheromones
- Dynamic UAV

Models of our study

Distributed Pheromone Repel model

- One pheromone map per UAV
- Marks the areas when they have been scanned
- Broadcast regularly a local area pheromone map (when a distance is inferior to 8 km)

Models of our study

Distributed Pheromone Repel model

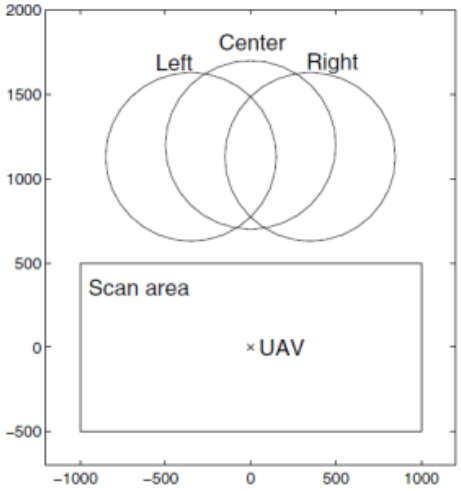


Figure 2. Pheromone search pattern

Table 2. UAV pheromone action table.

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

From : *"Mobility Models for UAV Group Reconnaissance Applications"*
By : *E. Kuiper and S. Nadjm-Tehrani.*

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
  - No excessive use of bandwidth (communication of 1 message/s/UAV)

Experiments

Expected results :

Scan the area in 40 min

Obtained results :

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

Experiments

Limitations

- Speed and shift (direction)
- Coverage and connectivity of communications are two conflicting objectives.
- Absolutely unrealistic !!!!!!

Comparison of 2 models

Scan characteristic

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

Table 3. Never scanned area

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

From : *"Mobility Models for UAV Group Reconnaissance Applications"*
By : *E. Kuiper and S. Nadjm-Tehrani.*

Our Implementation

All models

- Everything was done
- 10 nodes/models
- Margin calculation
- Percentage of scan
- Tracking display

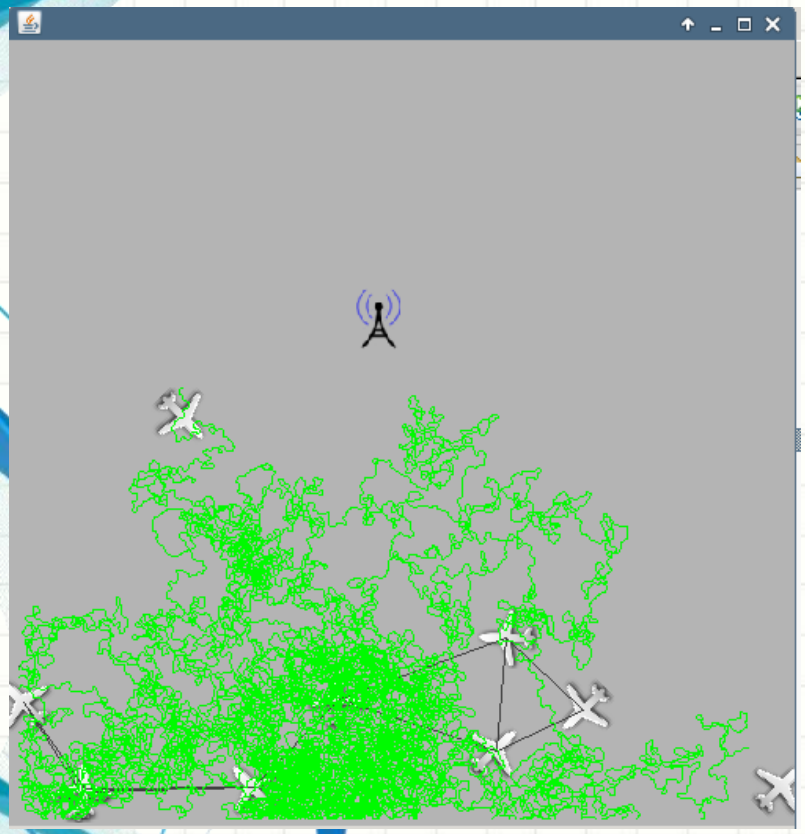
Pheromone model

- Presence of C&C does not move
- Communication

Our Implementation

JBotSim

Pheromone model



Problems @ Javadoc Declaration Consol

<terminated> Main [Java Application] /usr/lib/jvm/jdk-7-

```
Scan : 18.305705955851728% during 2 min 0 sec
Scan : 18.305705955851728% during 2 min 0 sec
Scan : 18.305705955851728% during 2 min 0 sec
Scan : 18.305705955851728% during 2 min 0 sec
Scan : 18.305705955851728% during 2 min 0 sec
Scan : 18.305705955851728% during 2 min 0 sec
Scan : 18.305705955851728% during 2 min 0 sec
Scan : 18.306122448979593% during 2 min 0 sec
Scan : 18.306122448979593% during 2 min 0 sec
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Scan : 18.306122448979593% during 2 min 0 sec
Scan : 18.306122448979593% during 2 min 0 sec
```
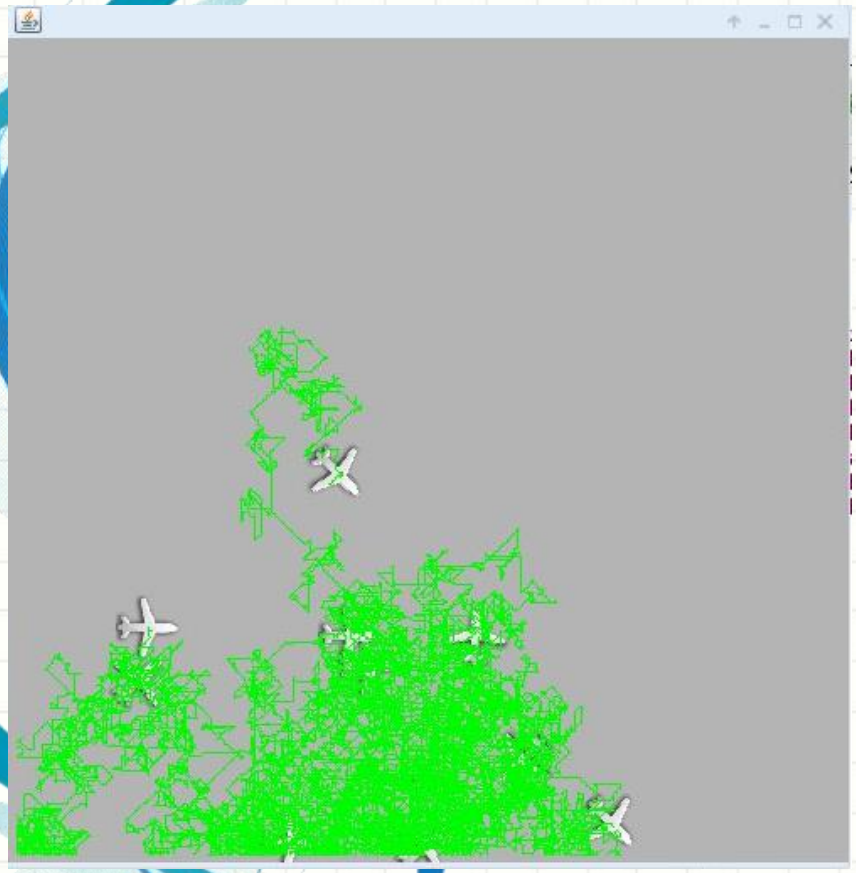

Our Implementation

JBotSim

Random Walk model



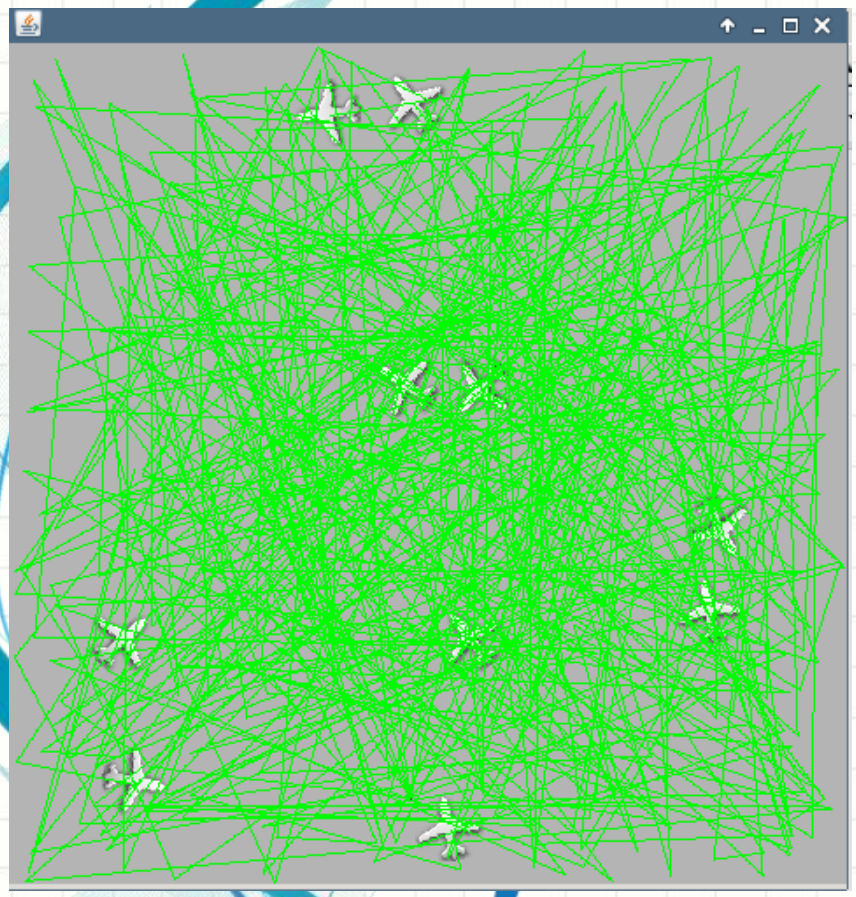
Problems @ Javadoc Declaration Consol

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

```
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

JBotSim



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
```

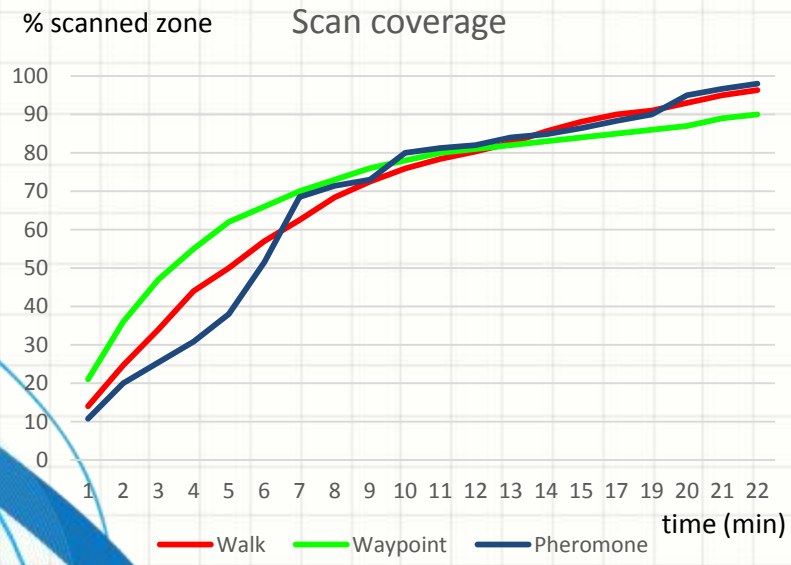
Our Implementation

Interpretation of results

- At the beginning, Random model more efficiency
- Pheromone : sharp increase because of C&C communication
- At the end, random models are stable
- Pheromone model is more effective that the others models to reach 100% of scan.

Our Implementation

Comparison with article



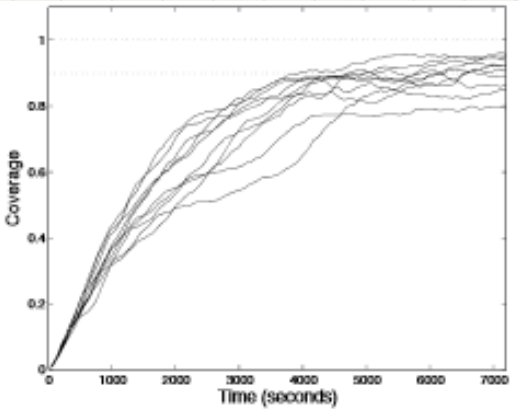


Figure 3. Random mobility coverage

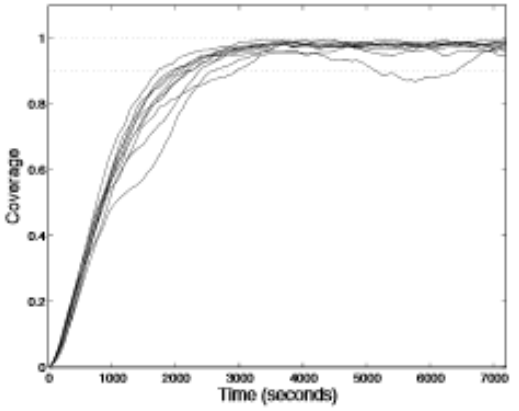


Figure 4. Pheromone mobility coverage.

Our Implementation

Importance of the Mobility Model choosen

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

Conclusion

- Good model for scan coverage and reconnaissance scenario.
- Absolutely unrealistic
- Possiblity amelioration is to temporary storage data and relax the limited bandwidth.

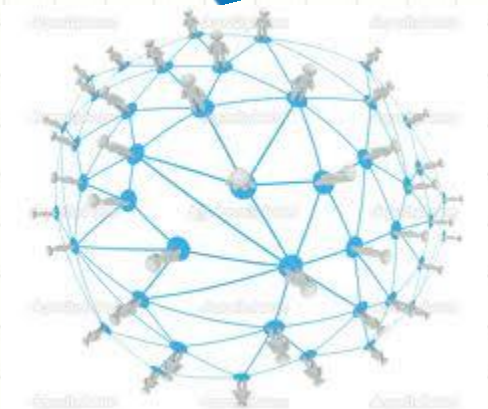


Figure 4. Source : " http://fr.depositphotos.com "

Figure 3. Source : " http://www.vikingaero.com "

Figure 5. Source : " http://titanaerospace.com "

DO YOU HAVE ANY QUESTIONS ?

Figure 6.

Ressources

- E. Kuiper and S. Nadjm-Tehrani.

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 "

[1] && [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