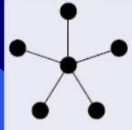



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# Muse Mobility, Ubiquity, Security

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## Goals and research topics of the Muse research group at LaBRI

Contribute to the definition and development of supporting middleware, tools and mechanisms formally validated that make it possible to take advantage in a secure way of the mobile resources which are wirelessly connected to the network and to develop applications on top of these resources.

### Target systems

→ Secured fleets of autonomous communicating mobile terminals ←

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# Keywords

mobility, mobile communicating systems, nomadic wireless/ delay and disruptive tolerant/peer-to-peer networks

distributed algorithms for mobile systems, models, validation

security, smart cards

tools, embedded and distributed middleware heterogeneity, adaptation and dinamicity management

mobile terminals, phones, drones, robots, fleets, swarms

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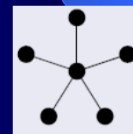
# Physical systems/fleets



(image courtesy the Smart Surface project)



Underlying dynamic graphs



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## Facts

- 17 Membres
  - 3 full time staff (1 rang A, 1 rang B) + 2\*0.5
  - 1 engineer + 1 to come (ISAAC project) + 1 to come (start-up creation support by AST)
  - 1 postdoc (currently at USMA West Point) + 1 to come (funded by RDECOM – US Army -)
  - 3 PhD students (1 with MF) + 1 (2?) to come in september
  - 5 internships
- Institutional support
  - Aetos UAV Cluster
  - Aerospace Valley Competitivity Cluster
  - Aquitaine Science Transfert
  - Région Aquitaine
- Academic collaborations
  - University of Luxembourg
  - VTT (Finland)
  - University of Le Havre, Bretagne Sud, Limoges, CNAM Paris
  - West Point US Military Academy
  - University of San Bernardino, University of North Texas

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## Facts (ctd.)

- Military, institutions collaborations
  - DGA (French Army), DRDC (Canada)
  - West Point US Military Academy, US Army Research Labs
  - French Firefighters, Museums, some major Cities
- Industrial collaborations
  - Gemalto, NXP, Thales, Dassault, etc.
  - Fly-n-Sense, FlyOps, Generation Robots, etc.
- Majors projects
  - 1 European project (Smart Urban Spaces)
  - 3+ projects under definition
    - FUI : West Point, Fly-n-Sense, San Bernardino, SDIS40, Le Havre, Luxembourg, Dassault (lead LaBRI)
    - NSF / ARL : West Point, Singapour, CRDC Canada, San Bernardino, DGA (lead West Point)
    - ICET 2 (lead Thales, Scientific lead Muse/LaBRI)

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## The nature of the network changes

- The nature of applications changes
  - group/community based, dynamic, ...
- The management/requirements of security changes

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## Paradigm shift for applications



How many people are there ?

Are there many people ?  
(or approximate number)



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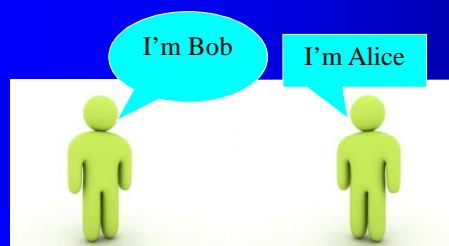
## Impact on applications

- The objectives must be lowered because of high instability
- Examples:
  - counting → lower bound
  - covering tree → covering forest
- But .. this is real life ☺

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## Paradigm shift for security



Share keys, authenticate

Recognize

- individually
- group/topic based



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## Impact on security

- The objectives must be lowered because of unsecure boudaries
- Examples:
  - entity based keys → group/topic based keys
  - authenticate → recognize
- But once again ... this is real life ☺

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## Research challenges and organization

- Distributed algorithms in a mobile context
  - Models
  - Possibility/impossibility results
  - Classes of graph
- Distributed Applications in real world swarms
  - Dynamic context
  - Extreme mobility
  - Autonomy
  - Build global decision/image from local decisions/pieces of information
  - Insecure boundaries

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# Distributed algorithms in a mobile context

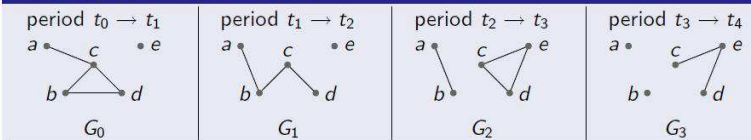
- Formal results
- Simulation library

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## Formalism to represent dynamic topology

### Evolving graphs [Ferreira 2004]



$$S_T = t_0, t_1, t_2, t_3, t_4$$

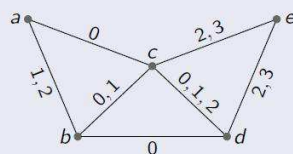
$$S_G = G_0, G_1, G_2, G_3$$

$$G = \bigcup_{G_i \in S_G} G_i$$

$$\left. \begin{array}{l} S_T = t_0, t_1, t_2, t_3, t_4 \\ S_G = G_0, G_1, G_2, G_3 \\ G = \bigcup_{G_i \in S_G} G_i \end{array} \right\} \mathcal{G} = (G, S_G, S_T)$$

is the corresponding *Evolving Graph*.

↓ graphical representation ↓



A.Casteigts, S.Chaumette, A.Ferreira

Characterizing Topological Assumptions of Dist. Algo. in Dynamic Networks

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Slide from Sirocco 2009

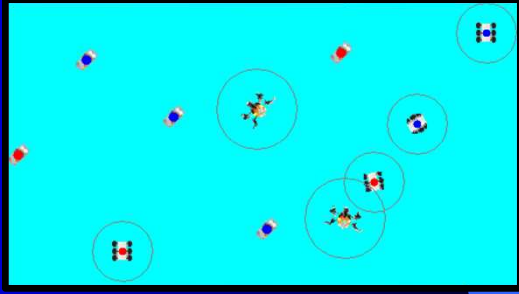




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# Simulation library

**The JBotSim Library**  
<http://jbotsim.sourceforge.net/>



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# Distributed Applications in real world swarms

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### The CARUS Project

Cooperative Autonomous Reconfigurable UAS Swarm

Logos on the left: LaBRI, albatros, THALES, Fly-n-Sense, Bordeaux Technowest, RETOS, REGION AQUITAINE.

Central diagram: A swarm of drones is connected to a 'Station Sol : Fly-n-Sense' (ground station) and a 'Visualisateur sol : Thales' (laptop). The swarm is labeled 'Plateforme flotte de drones : LaBRI/Fly-n-Sense'. Above the swarm is 'Algorithmique distribuée : LaBRI'.

Bottom text: CARUS – [serge.chaumette@labri.fr](mailto:serge.chaumette@labri.fr) Conférence de presse du 9 décembre 2011

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Top left: A circular logo with text: 'conditions de rimase', 'cité innovation', 'laboratoire', 'plumes de données gest', 'service réseau', 'application'.

Central diagram: A 'Mobile Device' (smartphone) displays 'Question #21'. It is connected to a 'Clue' application (represented by a blue 'N' logo) and a 'Piece of Art' (a mechanical structure). A compass rose is also present.

Logos on the right: CAENA, Musée de Normandie, smart urban spaces, UNIVERSITÉ DE BORDEAUX.

Bottom text: Chinese delegation visit at LaBRI, June 4th 2013; [serge.chaumette@labri.fr](mailto:serge.chaumette@labri.fr)

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## Museum Quest



- **Interactivité, immersion, fun**
  - stimulation de la curiosité et de l'intérêt
  - les enfants reviennent dans les musées
  - les visiteurs parlent ensemble
- **Tout fonctionne offline**
  - réactivité
  - pas de frais de connexion supplémentaire pour les touristes étrangers
- **Une véritable valeur ajoutée pour les musées**
  - le contenu peut être enrichi
  - une technologie de pointe
- **Business model**
  - une application unique pour chaque musée
  - développement et de réglage
  - mises à jour régulières





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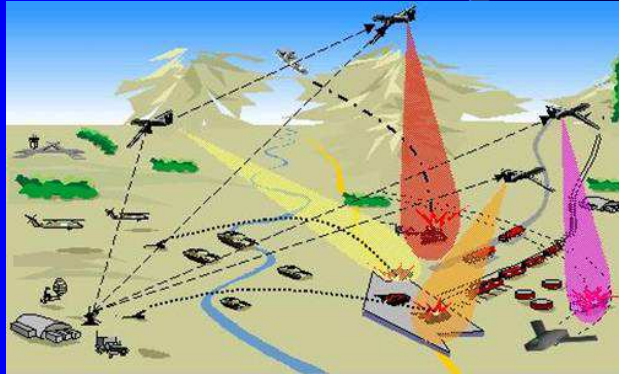
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# Future directions

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## Multilevel, heterogeneous swarming



Source : <http://www.cds.caltech.edu/~murray/projects/darpa01-mica/>

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## The swarms that we target

- Airborne systems
- Ground systems
- Underwater systems
- Sensor systems/embedded PDAs
  
- (micro level: MEMS, smart dust, etc.)

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## For doing what ?

- Be part of the of a global Cyber Physical System
- Civilian purpose
  - Rescue
  - Exploration
- Military purpose (situation management, etc.)



Source: <http://www.dfki.de/cps/>

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## What are the benefits?

- In terms of business
  - Cost effective solutions
  - New ‘unreachable’ territories can be explored
- In terms of human lifes
  - Increase knowledge
  - Support rescue
  - Avoid sending persons to dangerous areas

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## The benefits of a (heterogeneous) swarm


- Swarms: a swarm is not a fleet
- $1+1 > 2$ 
  - 2 coordinated systems are more powerful than two unconnected systems
  - Support new features
    - Example: combining UAVs and UGVs for a rescue operation clearly adds value

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## The problems with a single vehicle

- Localization
  - Still relies on some external system
    - A butterfly can cross the ocean, why don't we have the technology?
  - outdoors
  - Indoors
- Sense and avoid
  - A fly never crashes, why don't we have it?
- Communication
  - Depends on the environment



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## The problems with a single vehicle


- Autonomy
  - Still an issue
- Safety
  - Sense and avoid (see above)
  - What if a vehicle crashes?
- Privacy

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## The problems with a swarm

- Legal issues
  - 1 systems → 1 operator ☹
  - We are flying in segregated areas
  - How can we impact the regulation?
- Safety
  - What if one vehicle crashes?
  - What if one needs to be landed?



Source: <http://wallpapershi.net/birds-swarm-vortex-animal/>

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## The problems with a swarm

- Localization, Sense and Avoid
  - Close physical proximity between the vessels
- Authentication
  - Unsecure boundaries remain an issue
  - Applications need to be thought of differently
- Communication/computations
  - Many units → many communication channels
  - P2P + local decisions/computation
- Local decision → global emergent decision

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## The problems with different swarms

- Communication
  - Issues when changing environment
    - Air to underwater ...
- Different mobility/communication/computation loops

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## Major directions that should be further explored

- Models
- Local computation based approaches
- Localization, sense and avoid
- Authentication, id. management
- Management by the operator + regulation
- Mobility/communication/communication loop management

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