Wireless Sensor Network based Monitoring, Cellular Modeling and Simulations for Environment

Onil Nazra Persada Goubier, Hiep Xuan Huynh, Tuyen Phong Truong, Mahamadou Traore and the SAMES group
SAMES (Stic Asia Modeling for Environment and Simulation) Group

- Researchers
  - France:
    - University of Bretagne Occidentale / LabSTICC as leader (B. Pottier, V. Rodin, B. Nsom, L. Esclade), CIRELA Paris (O. Goubier) IRD Paris (S. Stinckwich)
  - Vietnam:
    - Cantho University (HX Huynh, BH Lam ), IFI Hanoi (Vinh)
  - Indonesia
    - BPPT Jakarta (Udrehk, Hafidz Muslim), DRR Foundation Indonesia (Surono)

- Objectives:
  - to develop software tools to ease wireless distributed sensing and data integration in relation with critical physical processes.
Physical Phenomena:
- water flow, flooding, pollution, volcano, insect invasion, ...
Environment and climate change issues
- Reduce Risks of natural and environmental disasters
- Knowledge on physical phenomena
- Real time monitoring
- Life in harmony with the environment
Plan

- Wireless Sensor Networks, an overview
- Geo-localized Cellular Modeling and Simulation
  - PickCell/Netgen modeling tools
- 2 cases:
  - Line of sight
  - Desert locus invasion
- Current cooperations
- Potential cooperations
Wireless Sensor Networks
Wireless Sensor Networks

- A WSN measures values representing the state of a physical system
  - Distributed measurements for physical phenomena
  - Space and time

- Sensors:
  - Measure values,
  - ex. flood monitoring and warning:
    - water level, flow rate, ...
Wireless Sensor Networks

- Networks
  - mesh, hierarchical, ...
  - ZigBee, SigFox, LoRa, Cellular IoT, LTE-M, GPRS, …
  - Low cost, low power and low rate communication
Wireless Sensor Networks

- Information System (IS)
  - Collected data to IS → Database server
  - External sources

- Data used to:
  - Monitoring, Modelling, Simulation, Forecasting, Decision Support

- Dissemination:
  - Web technology, handphone applications
Geo-localized Cellular Modelling

- Cellular model to study a physical phenomenon and measures taken from a WSN from the same geographical area
- Coverage:
  - Sensor locations
  - Number of Sensors
  - Periodicity
Geo-localized Cellular Modelling

- Represent a physical phenomenon
- Physical evolution of this phenomenon
- Interaction between a physical phenomenon and a WSN
PickCell
Cellular Automata
- A cell represents a local state of a physical phenomenon
- System evolution is based on neighborhoods:
  - Von Neumann or Moore

- Communication between cells
- Rules describes how a cell changes at each time step
Line of Sight Computation

- Problems:
  - how to manage sensors deployments to overcome physical constraints and to get better coverage
  - And reduce cost!
  - How well sensor networks can sense a physical phenomena in an area → network sensing coverage

- Collective measures:
  - Sensor positions, number, precision
  - Radio propagation,
  - Radio technology
  - Ground contour, ...
Line of Sight Computation

- Radio propagation
  - a physical phenomenon
  - a logical connectivity between nodes (in cell system).
- Radio propagation can be stopped or attenuated by ground topology (hills, valley).
  - Free Space Path Loss Model
  - Model with Diffraction
Simulate the physical behaviour by:
- propagating the signal inside a tree rooted at the emitter cell,
- and covering all the space in concentric circles.

During radio propagation,
- the ground profile is collected into routes that are completed progressively based on positions and elevations.
- Each cell decides if the emitter is visible or not by comparing its elevation to the received profile.
Line of Sight Computation
Still much work to be done
More parameters to take into account:
- More obstacles
- Number of sensors, locations
- Radio technology: LoRa, ZigBee, …
- …
Desert Locust Invasion

- Research with Senegal and Madagascar
- Desert locusts change their behavior, physiology and morphology, in response to density variations.
- This change happens on short time and space scales preferentially in breeding areas known as locusts invasion starting point
- Two different behavioral phases:
  - Solitarious:
    - individuals live in a sparse and scattered manner in Sahel countries
    - do not venture and do not affect agricultural production.
  - Gregarious:
    - responsible for considerable damage caused to crops
Desert Locust Invasion

- Outbreaks happen only within specific conditions, leading to huge swarms, trying to survive by flying for other food sources and for escaping predators.
- They migrate from one area to another for a better living condition, and die if they fail to find a suitable breeding area.
- Emigration concerns winged individuals who turn to solitarious and then to gregarious before flying in a swarm.
Desert Locust Invasion

- Desert locust physical system:
  - the locust population in their breeding area and their interactions with weather, vegetation cover and wind, evolving from eggs to adults and flying to other cells, laying eggs.
Desert Locust Invasion

- **Cell model:**
  - each cell contains
    - eggs, larvae stages 1 to 5, winged, solitarious and gregarious individuals.
  - Each array is subdivided in micro states representing the corresponding individuals life cycle period.
  - Two cases:
    - local transition between micro states in a cell.
    - migration between cells
Desert Locust Invasion

- Local transition between micro states in a cell
Desert Locust Invasion

- Work still in progress
  - Migration of locusts
  - More parameters:
    - Weather, wind, vegetation cover, ...
    - Geo-localized with WSN
    - ...

[Image of ICT-BioAsia 2016 Workshop logo]
Current Cooperation

- Experimentation with LoRa in Vietnam
Current Cooperation

- Experimentation with LoRa in Vietnam
Current Cooperation

- Experimentation with XBee in Indonesia
Current Cooperation

- Experimentation with XBee in Indonesia
Current Cooperation

Next:
- Apply line of sight computation for Indonesia and Vietnam examples
- More applications:
  - Modeling floods: Indonesia, Vietnam, ...
  - Modeling insect invasion:
    - Vietnam, Senegal, ...
• Many cases and applications in environment, in case of green smart cities
• We are open to cooperation with additional partners
Thank you
Merci
Cảm ơn
Terima kasih