Dependable k-coverage algorithms for sensor networks

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Dependable k-coverage algorithms for sensor networks

Outline

- Cooperation project BALATON
- Project goals: dependable web services based on dependable networking
- Dependable measurement: k-coverage
- Problem of sensor powers
- Related works
- Scheduling proposition based on a drowsiness factor
  - Centralized and distributed versions
- Perspectives

Dependable k-coverage algorithms for sensor networks

- **Cooperation project BALATON**
  - Intergovernmental cooperation
  - Limited budget
    - Two short missions per year in each country
  - Partners : Department of Measurement and Information Theory
    - Measurement, Web services, formal methods
    - Dependable systems, computing
    - MITMOT plate-form

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- **Project goals: dependable web services based on dependable networking**

"Dependable web service architectures for real time applications in intelligent networks"

  - Dependable Web service architectures based on SN
  - UML models (design patterns)
  - Dependable communication, routing
  - Pilot application

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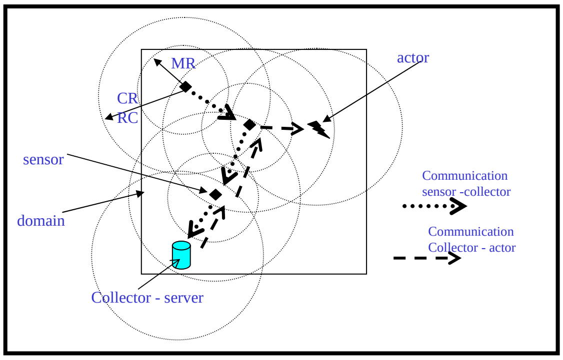
- **Sensor networks**
  - Ad hoc networks without infrastructure
  - Sensors and actors
  - Mobiles or not
  - Collect of data
  - Services
  - Control



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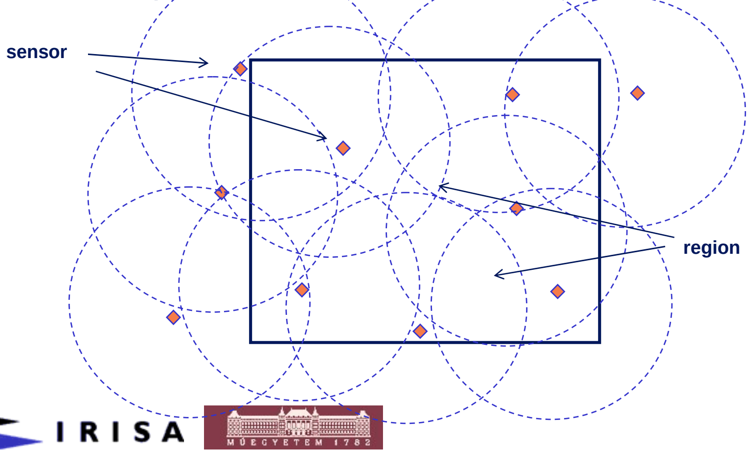
- **Dependable measurement: k-coverage**
  - some *technologies* and the *dependable aspect* need multiple observations / measurement of a same value



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Dependable k-coverage algorithms for sensor networks

- **Dependable measurement: k-coverage**
- **Problem of sensor powers**
  - sensors are dotted with autonomous batteries
    - lifetime ~ 48 h
  - Measurement and communication consume power
  - Idea
    - Put a lot of sensors in the area (over-dimensioning)
    - Alternate awake and doze states (turn off certain sensors)
    - Constraints:
      - k-coverage
      - Power

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- **Related works**

- Nadeem Ahmed,Salil S. Kanhere and Sanjay Jha, *The holes problem in wireless sensor networks: a survey*, in SIGMOBILE Mob. Comput. Commun. Rev., 2005. vol(9), no (2)
- Chi-Fu Huang and Yu-Chee Tseng. *The coverage problem in a wireless sensor network*, WSNA '03: Proceedings of the 2nd ACM international conference on Wireless sensor networks and applications, 2003.
- Ronny Krashinsky and Hari Balakrishnan. *Minimizing energy for wireless web access with bounded slowdown*, MobiCom '02
- Lawrence S. Brakmo, Deborah A. Wallach and Marc A. Viredaz. *Sleep: a technique for reducing energy consumption in handheld devices*, MobiSys '04
- Chih-fan Hsin and Mingyan Liu. *Network coverage using low duty-cycled sensors: random & coordinated sleep algorithms*, IPSN'04
- Benjie Chen, Kyle Jamieson, Hari Balakrishnan and Robert *Morris,Span: An Energy-Efficient Coordination Algorithm for Topology Maintenance in Ad Hoc Wireless Networks*, Wireless Networks,vol(8), no(5), 2002.
- Santosh Kumar, Ten H. Lai and Jozsef Balogh}, *On k-coverage in a mostly sleeping sensor network*, MobiCom '04

Dependable k-coverage algorithms for sensor networks

- **Related works**

- **Random scheduling**
  - **Each sensor decides to go to sleep with probability p=k/m**
  - **Lifetime is prolonged with m/k**
  - **Without communication cost**
  - **Does not guarantee the k-coverage**

- **Coordinated sleeping**
  - **k-coverage is assumed**
  - **Important communication between nodes and election of sleeping sensors**

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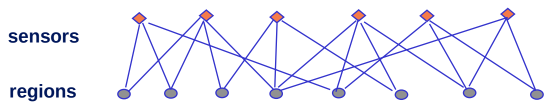
Dependable k-coverage algorithms for sensor networks

- **Scheduling proposition based on a drowsiness factor**
  - **Graph of dependences: bipartite graph**



  - **Coverage ration of a region:**

$$\Phi_r = \begin{cases} \frac{1}{c_r - K} & \text{if } c_r > K \\ -1 & \text{otherwise} \end{cases}$$

  - **Drowsiness factor of a sensor:**

$$D_s = \frac{1}{E_s^{\alpha}} \sum_{\forall r \in R} \Phi_r \delta(r,s)$$

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- **Scheduling proposition based on a drowsiness factor**
  - **Centralized version**

1. Run the network for a period of T
2. Wake up all sensors which should send state information
3. Calculate drowsiness factor for each node.
4. Select the node with the largest positive drowsiness factor. Send this node to sleep if it is possible (k-coverage).
5. Repeat Steps 3-4 while possible (i.e. there is at least one node with positive drowsiness factor).

- **Note : if a sensor does not receive a *go to sleep* message, it remains the active state**

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- **Scheduling proposition based on a drowsiness factor**
  - **Distributed versions**

1. Run the network for a period of T
2. Wake up all sensors and broadcast its state locally
3. If the time out Td1 arrives, calculate drowsiness factor and broadcast it in the neighborhood (the same if there is changes)
4. If a message is received, store the received drowsiness f.
5. If the time out Td2 arrives go to 6, else go to 4
6. If the node is the node with the largest positive drowsiness factor, make the decision and broadcast the local decision (eventually, go to sleep).
7. If a message is received recompute the factor and broadcast it if necessary and go to 6.
8. If the time out Td3 arrives, make the final decision

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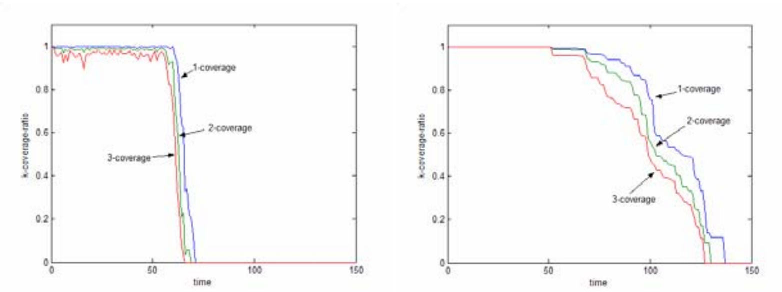
■Some results



The performance of the random (a) and the proposed centralized (b) algorithms for a randomly distributed sensor network containing 100 nodes

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■Perspectives

- Improvement and performance analysis
  - Region tail
  - Robustness and security
- Routing solution
  - In-cast tree
  - Direct diffusion
  - Clustering
  - Fault tolerance, protection
- web services
  - Heterogeneous network
  - Reactive or proactive measurement
  - QoS parameters
- Implementation MITMOT

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