Experimental Evaluation of Resilience for Ubiquitous Mobile Systems

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Motivation

- Why are you attending this workshop ?
  - Ubiquitous systems are difficult to evaluate
    - Usability, Acceptance, Performance, Resilience
  - Analytically: need for models, tools, etc.
  - Experimentally: need for platforms, prototypes, benchmarks, metrics, data, applications, etc.
- Why is it so difficult ?
  - What are ubiquitous systems ?
  - Scale (#/size devices/environment)
  - What to evaluate ?
    - User experience, network parameters, etc.

From prototyping to evaluating

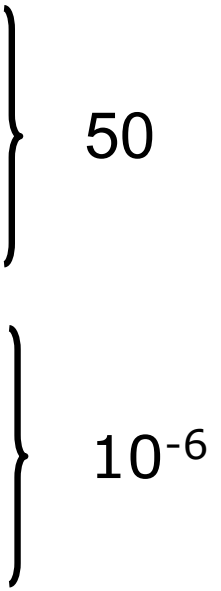
- We need/have/want to build prototype
  - Prototyping ambient-ubi-mobile critical systems?
  - How to evaluate their properties/resilience?
  - Can we create a benchmark?
- Ubiquitous systems are very diverse
  - VANETs
  - Urban social networking
  - Nano-robots
- Can we have a unified approach
  - Scale, scale, scale

Experimental platform

- Typically composed of fixed and mobile devices
  - Programmable mobile platform
  - Light processing unit
  - Wireless comm. interfaces (adhoc+infra)
  - Positioning device
- Dedicated laboratory
  - Infrastructure
    - Computing, communication, positioning
  - Reproducible experiments
  - Fault injection
  - Different scales

Scalable lab !

- Different prototypes ➔ different scales
  - Communicating vehicles (VANETs)
    - Device: 3m
    - Environment: 1km road
    - Communication range: 100s m
  - Cooperating nano-robots
    - Device: ∅1μm
    - Environment: ∅20μm vessel
    - Communication range: 10s μm
- Scale increase or decrease
  - Factor from 10^{-6} to 10^{2}

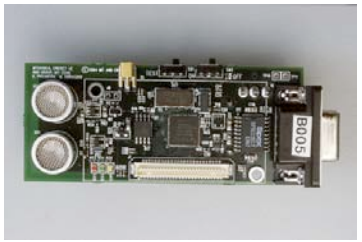


What are the issues to solve

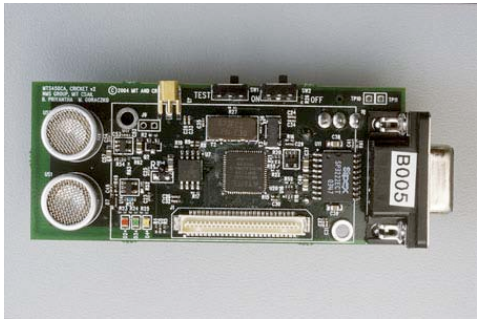
- Constraints
  - Reproducible and characterized
  - Variable scale
  - Indoor
  - Cost
- Technical issues
  - Precise indoor positioning
  - Programmable mobility
  - Range-controlled communication

Precise Indoor Positioning

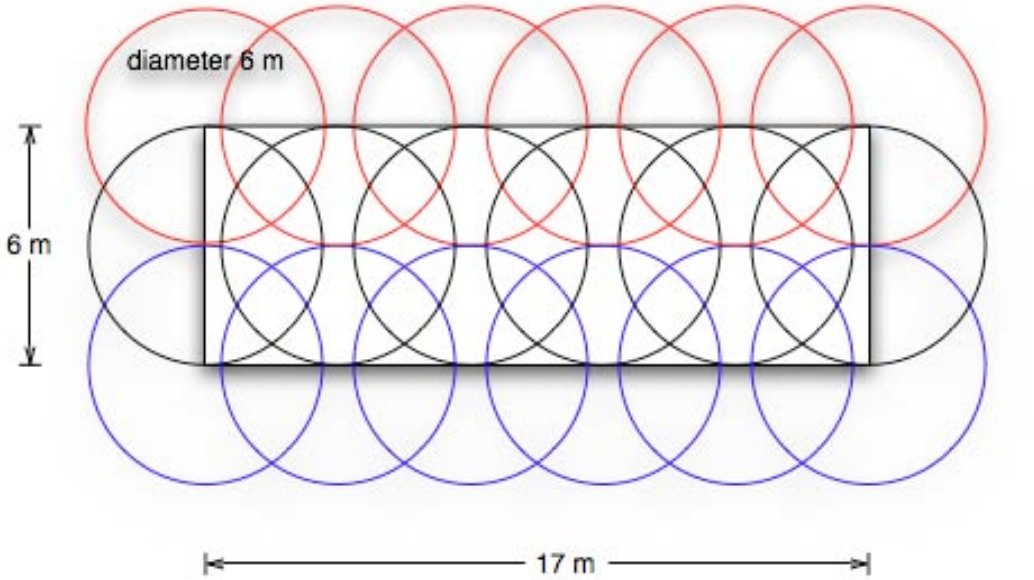
- Desired precision
  - In-vehicle GPS ≈ 5m
  - Scale reduction factor 50
    - Indoor precision ≈ 10cm
- Several technologies
  - Scene analysis (motion capture)
  - Triangularization (RF, ultra-sound, UWB, etc.)
  - etc.
- Cricket
  - Precision ≈ 2-3cm
  - Accuracy, Cost



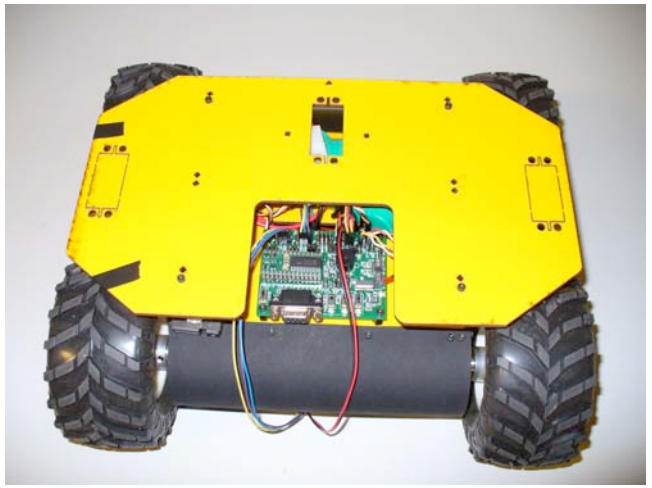
Cricket deployment



- Lab 100m^2 : 6x17m
- Crickets range ≈ ∅6m
  - 18 crickets for the infrastructure
  - Any place covered by 2 crickets

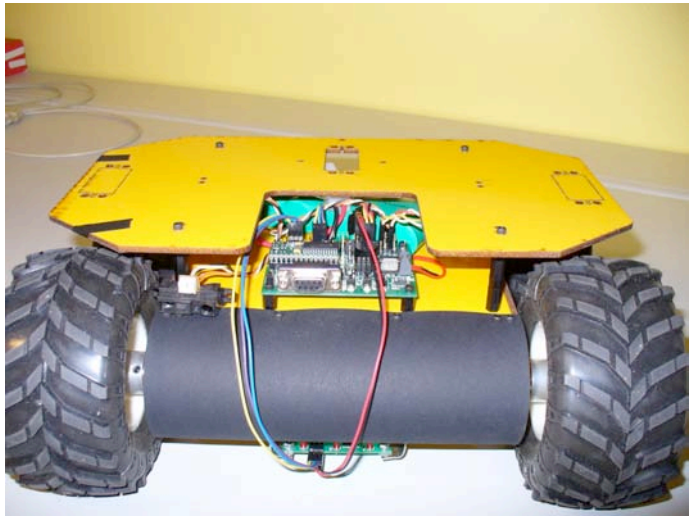


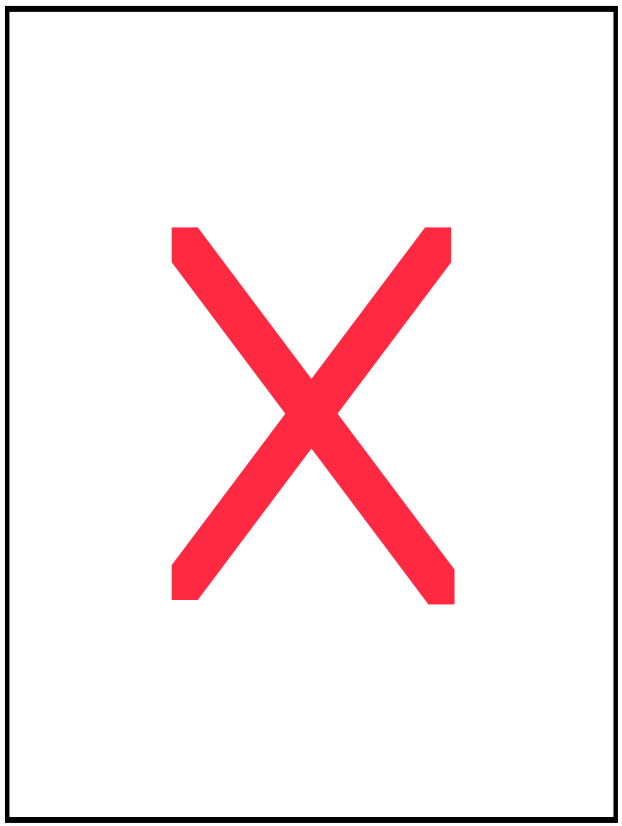
Programmable Mobility



- Reproducible Mobile experiments
  - Small robot platforms
    - Carry PDA or laptop
- Different designs
  - Tape tracks
    - Precision is « OK » and making progress
    - 20cm/s for a few hours
    - « Remote-controlled » using infrared
  - Cricketized version
    - Better precision
    - Increased speed (expect 60cm/s for 200+ km/h)

Lynxmotion 4WD



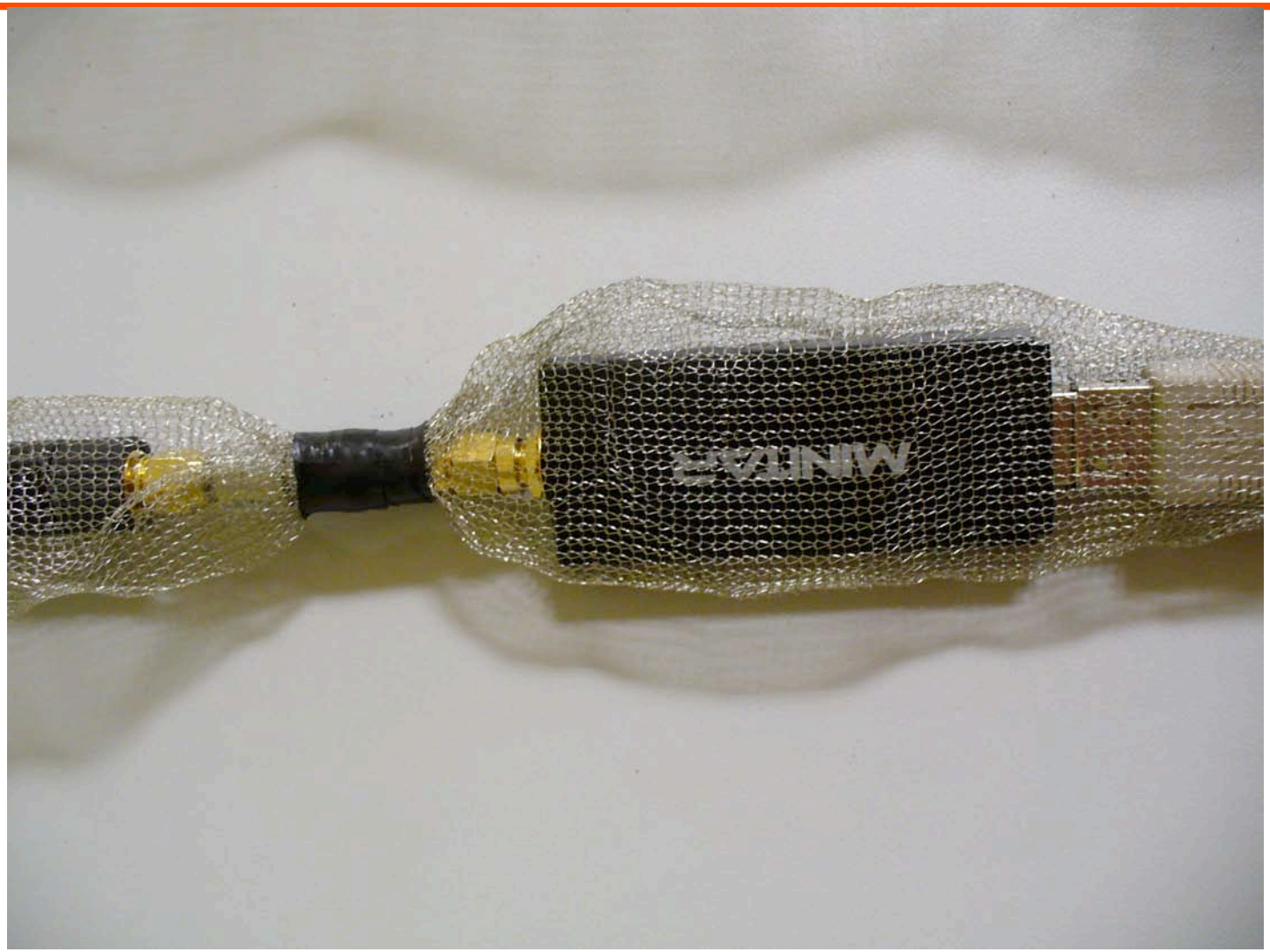


The BIG issue: wireless communication

- 2 technical questions
  - How to scale down WIFI ?
    - Hundreds meters ➔ few (2-3) meters
    - Precisely and controlled
  - How to build communication obstacles ?
    - Tunnels, mountains, buildings, etc.
- Potential solutions
  - Via emulation
  - Reducing Tx power of adapters
    - Access driver, Signal attenuators
  - Faraday cages, tents, etc.

WIFI USB key+ external antenna + attenuators + faraday socks

Attenuators



The resulting platform

How to validate the platform ?

- Evaluate each part (mobility, position., comm.)
  - Accuracy, precision, speed, cost, etc.
- Evaluation via benchmarking
  - Representativity, validity
    - Check against « reality » ?
    - Use community data sets, such as Crawdad
  - Reproducibility
    - Stability of the results of repeated experiments
    - Do not forget concurrency
      - Some variability is normal (desirable?)
      - But can be measured

Pros and cons / simulation

- More expensive than simulation
  - Money, time, space
- Closer to real systems
  - Real software (application, middleware, OS)
  - Integration
  - Hardware prototyping
  - Real mobility, positioning, etc.
- ➔ For critical systems
  - A prototype is to be developped
  - Spend a few bucks to evaluate resilience

Conclusion

- Ubiquitous (mobile) systems are hard to evaluate
  - Models, Metrics, Approach, Tools, etc.
- Evaluation of resilience is even worse
  - Fault/failure models
  - Fault injection
- Prototypes are necessary
  - Controlled environment: for evaluation
- Open issues
  - Validation, simulation
  - Fault-injection (accidental/malicious!)

Nano-bot engines at LAAS-CNRS

Costs

- Positioning Infrastructure ≈ 3 k€
- Nodes
  - Communication ≈ 50 €
  - Robots ≈ 500 €
  - Cricket ≈ 200 €
  - Laptop ≈ 1k€

- Total
  - 4 nodes ≈ 10k€
  - 8 nodes ≈ 15k€
  - 16 nodes ≈ 30k€

Panel : Ubicomp is so vast
How to characterize it ?

- From nano-robots
  - A few micrometers
- To planet-wide systems of systems
  - RFIDs, PAN, Home, Urban, VANETs, WANs, etc.
- Identify a few typical application model/props ?
  - # entities, # administration domains
  - Cooperation vs. Individual behavior
  - Mobility models
  - Resilience to accidental/malicious faults
    - Fault/failure models, desired resilience props
  - Performance related props