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Institut de Recherche sur les Composants logiciels et matériels pour l'Information et la Communication Avancée

From smart labels to wireless sensor networks

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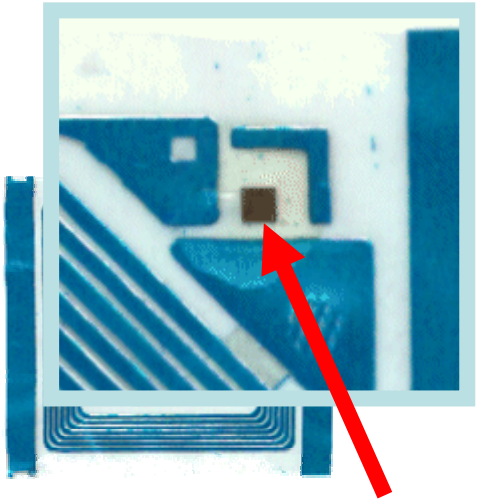
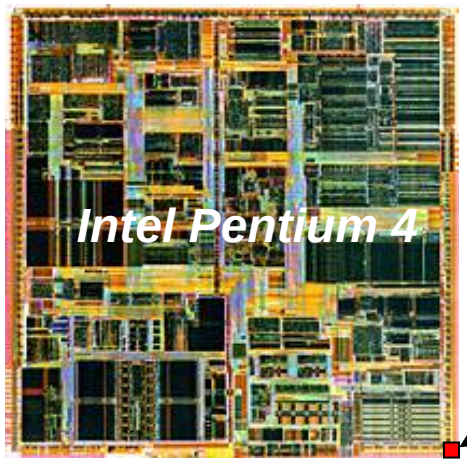
RFID Tags

- **Smart labels**
  - Radio Frequency Identification Tag
  - By opposition to **bar code** which use **optical** principles
- **A strongly limited component:**
  - 500 times smaller than a classical microprocessor



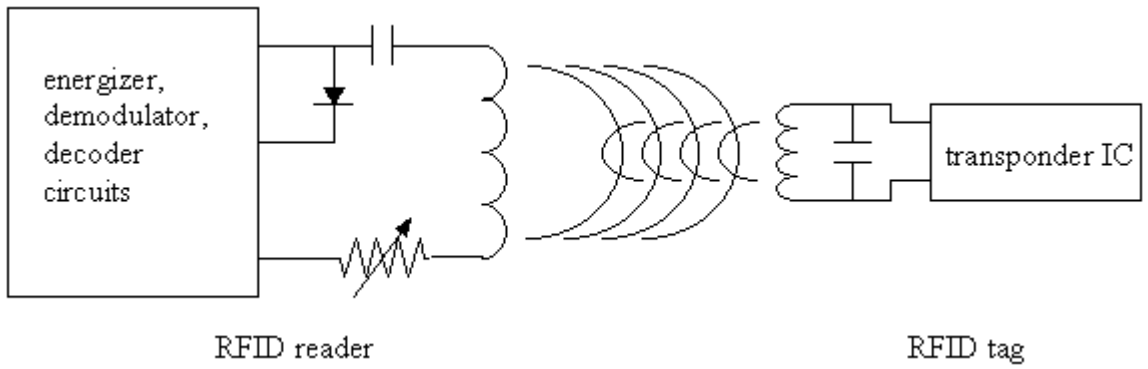
Chip with a size of some mm²



RFID Tag

Principle

- Typically, RFID Tags are passive components: they have no battery!
- Tag are powered by electromagnetic field generated by reader
  - Communication from reader device to vicinity tags: amplitude shift keying (ASK)
  - Communication from tags to reader device: impedance shift keying (ISK)



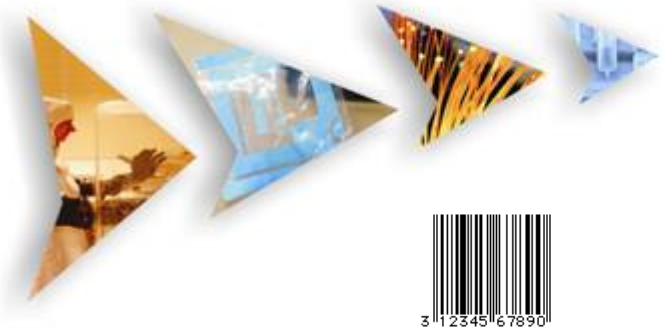
courtesy Intersoft

EAS Application

- **Electronic Article Surveillance**
  - Once powered, the tag emits
  - The reader listen channel and activate alarm as early as transmission is detected
  - During checkout, the tag is burned out
  - Problem: power and hear the tag whatever the tag orientation

Current smart labels

- **RFID Tag can memorize information**
  - Up to 256 bytes for present generations
  - Rewritable (flash memory)
  - Or not (write once)
  - Can be protected by password



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Substitute of bar code

☺ **Low-cost bar code**
- less than one cents (€)

☹ **High cost for interrogator device**

☹ **Static information**

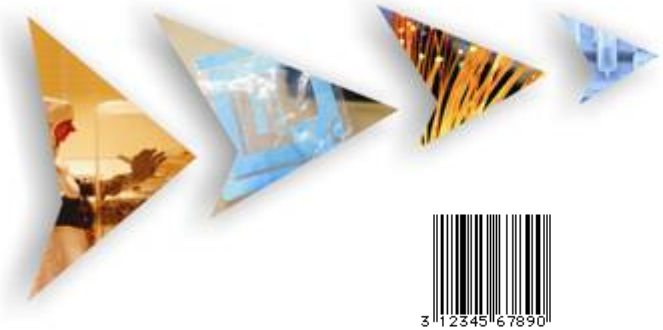
☹ **Limited information**
- ~ ten digits (decimal)
- *NB. Systemd that extend bar code capabilities exist (code-barre 2D, etc…)*

☹ **High-cost tags**
- Ten cents (€)

☺ **Lost cost for interrogator device**

☺ **Dynamic information**

☺ **Significant information capability**
- Kilobit order ~ several digit hundreds



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Substitute of bar code (2)

☹ **Provided information concerns a collection of objects and requires centralized system**

☹ **Security relies on centralized system**

☹ **Unidirectional optical communication**

- Direct line of sight
- Handling
- Sensitive to dust
- …

☺ **Information relative to the object**

- Can be completed by centralized system

☺ **Security at tag level**

- *Fight against falsification*

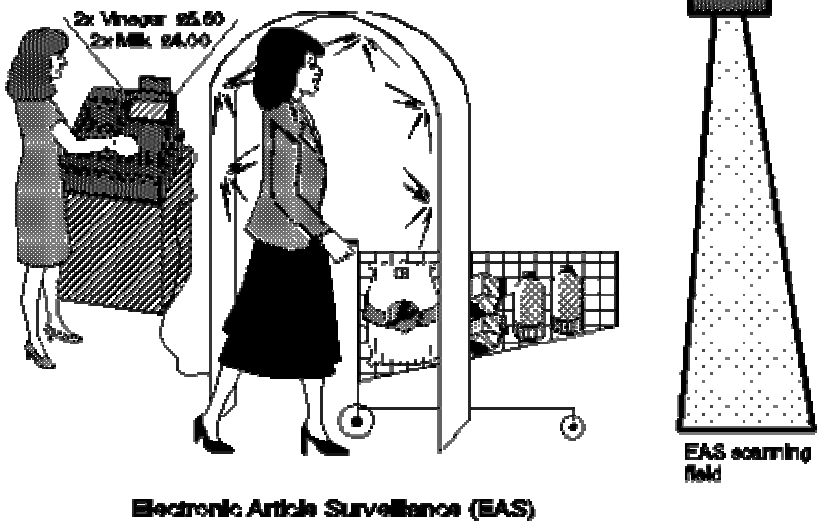
☺ **RF communication**

- No Line of Sight

Substitute of bar code (3)

☹ **Item by item scanning**

☺ **Scanning of set of items**



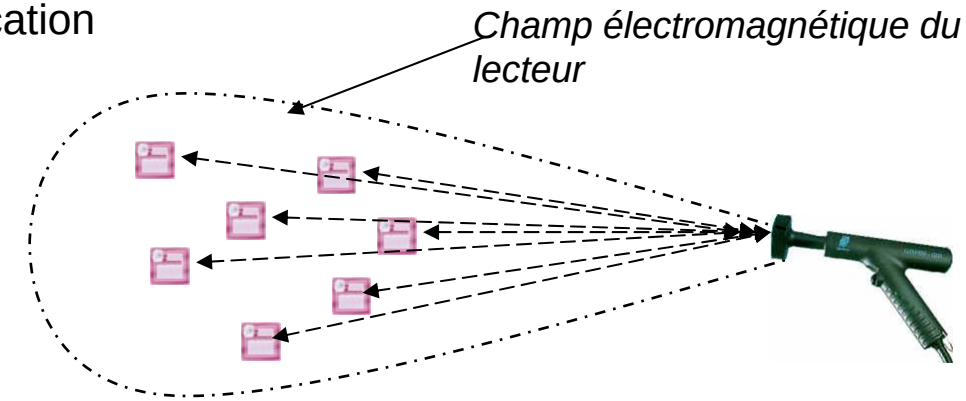
Electronic Article Surveillance (EAS)

courtesy to Mike Marsh

- *Batch identification*
  - No handling
  - Fast identification
    - ✓ More than 200 tags per second

Batch identification protocols

- **Protocol which aims to collect without error all ID or data of tags while minimizing identification time**
  - Collision management (simultaneous transmissions)
  - Avoid tag missing/lost
  - Maximize identification speed
  - Maximiser la vitesse d'identification
- **It is MAC layer (medium access)**
  - Aloha
  - CSMA/CD, FDMA, CDMA too complex…
- **Dedicated protocols**
  - SuperTag (Aloha)
  - TIRIS de Texas Instrument (tree based algorithm)
  - I•Code de Phillips (idem)
  - STAC de TagSys/LIFL (adaptive round)
- **Centralized configuration**
  - Intelligence in interrogator device ⇒ simple and low-cost tags



Applications

Batch identification

Marathon
Automatic clocking in

Automatic luggage sorting

Automatic inventory
50 items in less than one second

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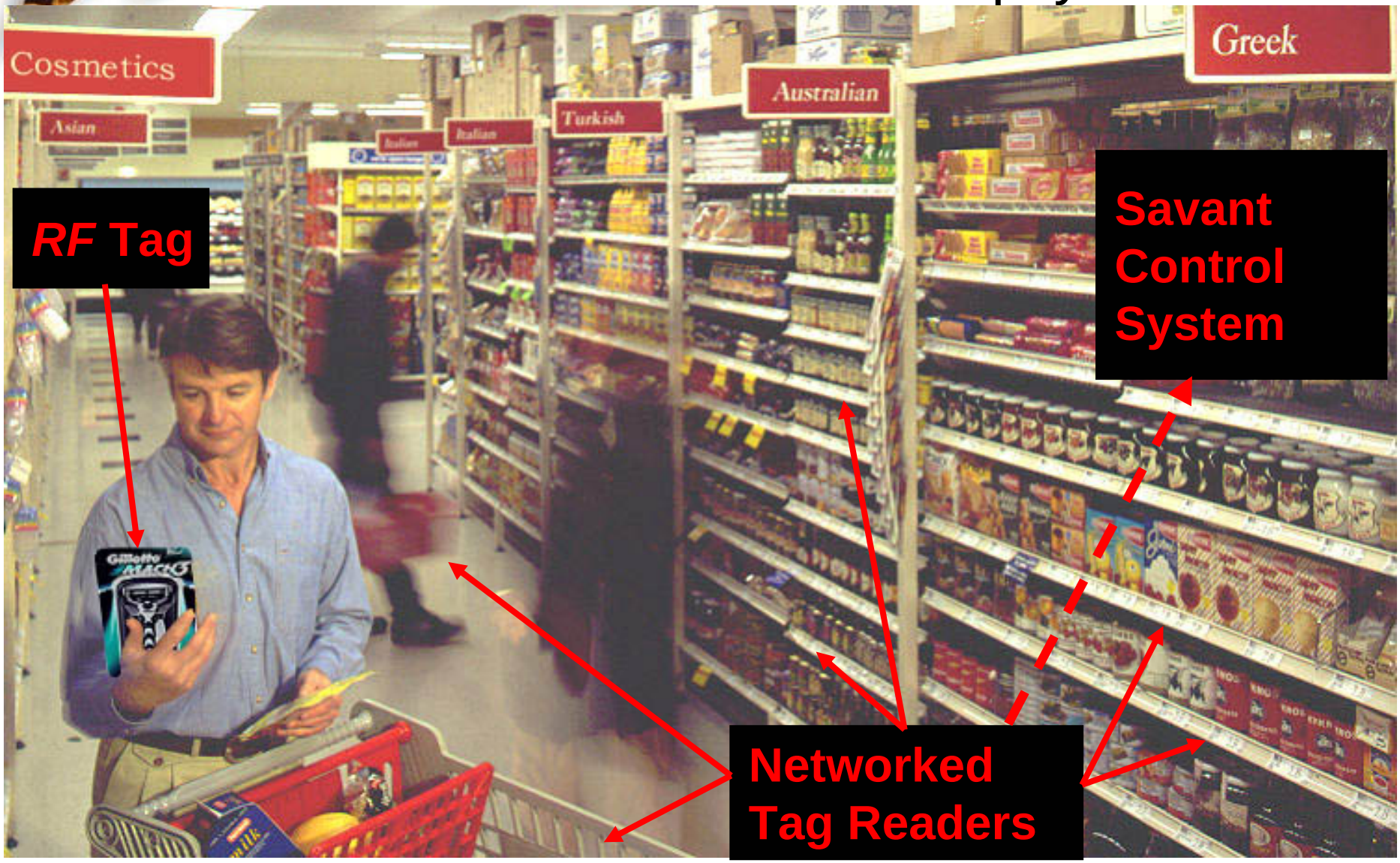
Networking the physical world



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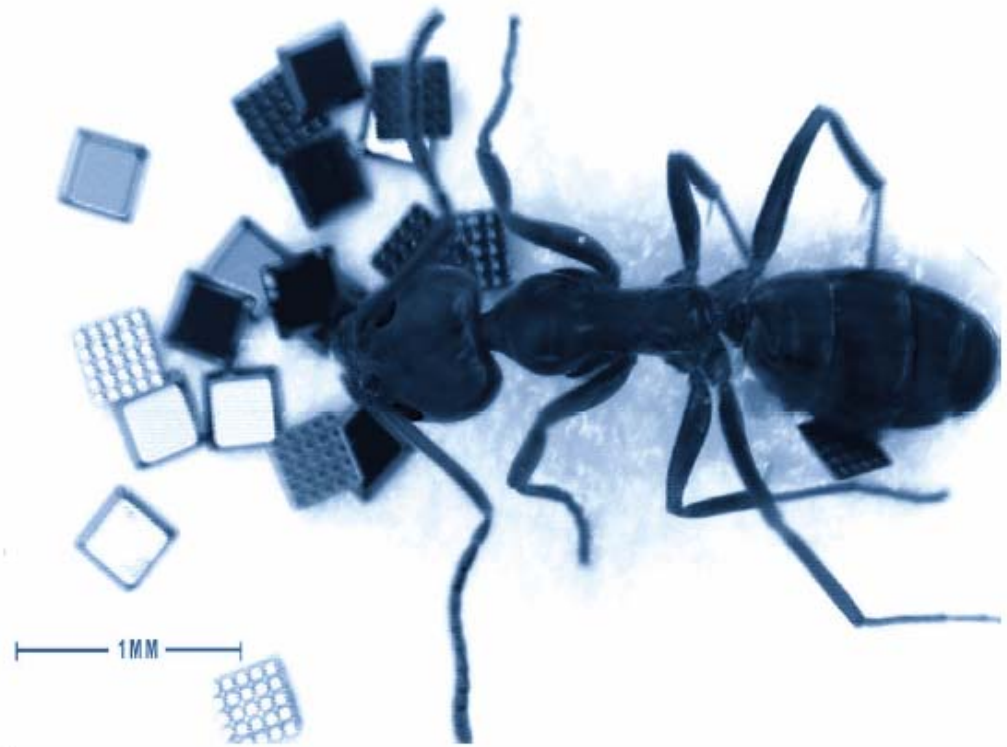
More POPS, smaller POPS...

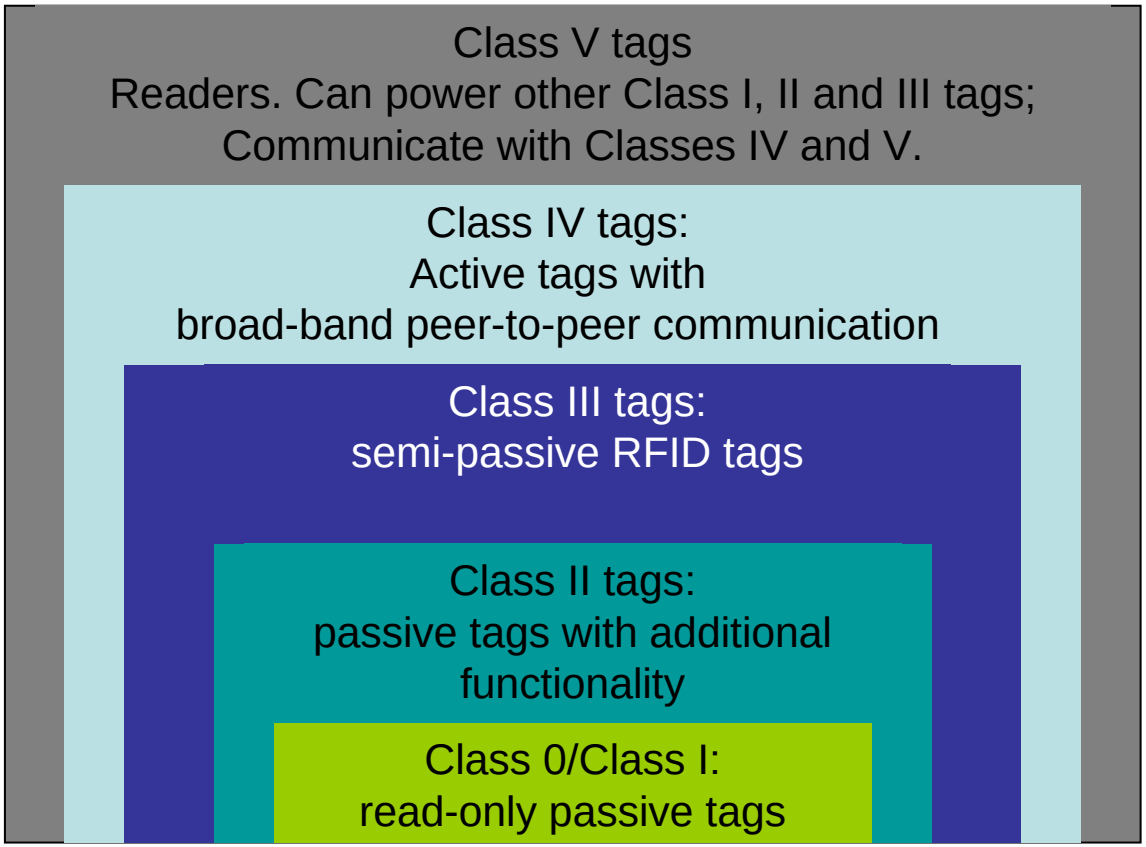
* POPS = Portable Objects Proved to be Safe
(*e.g.* smartcards, RFID, sensors, smastdust…)



The MIT Auto-ID Center Vision of "the internet of things"

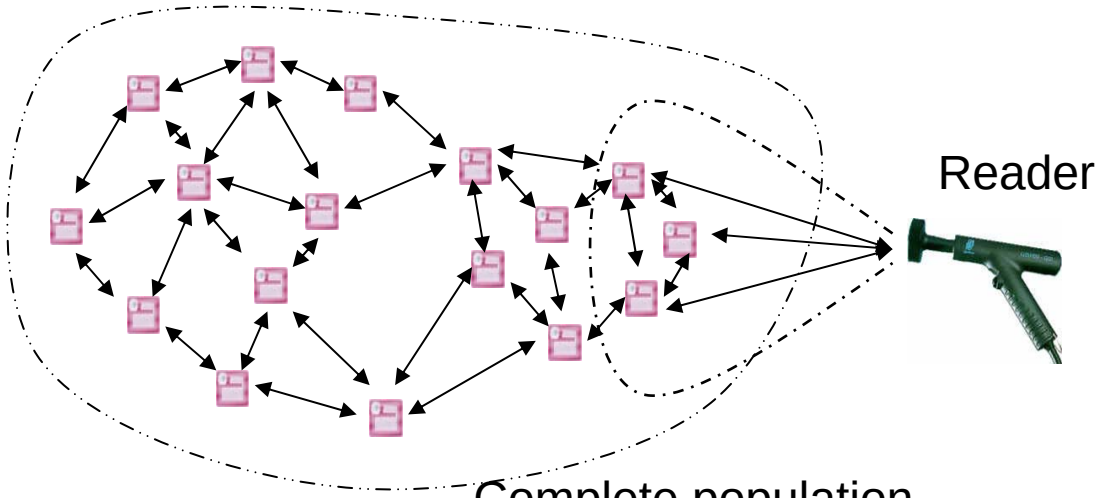
Courtesy, Auto-ID Center

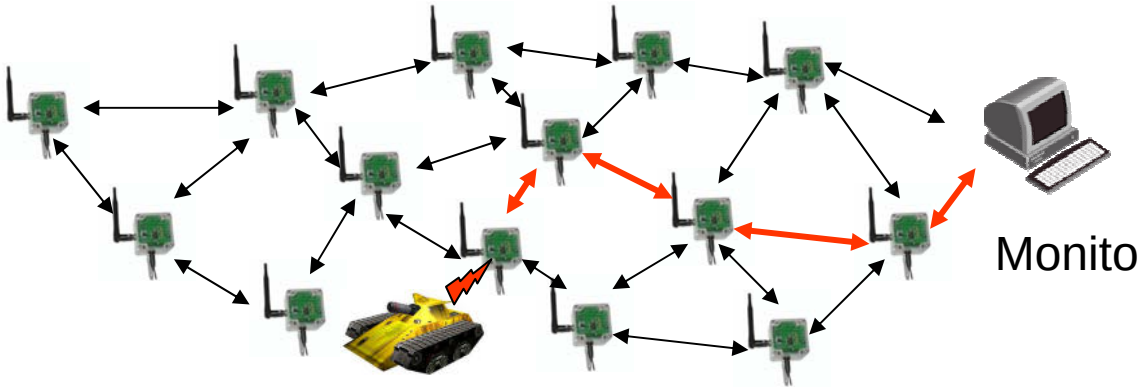
Auto-ID Center classification



Benefits of class IV tags

- **Decentralized behavior**
  - The request is broadcasted in the whole network by using multi-hop method
- **Similar to sensor networks**





Sensor applications

- **Military applications:**
  - (4C's) Command, control, communications, computing
  - Intelligence, surveillance, reconnaissance
  - Targeting systems
- **Health care**
  - Monitor patients
  - Assist disabled patients
- **Commercial applications**
  - Managing inventory
  - Monitoring product quality
- **Misc.**
  - Monitoring disaster areas
  - Home security

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Sensor Nets for Search and Rescue

- **Inactive Sensor**

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Sensor Nets for Search and Rescue

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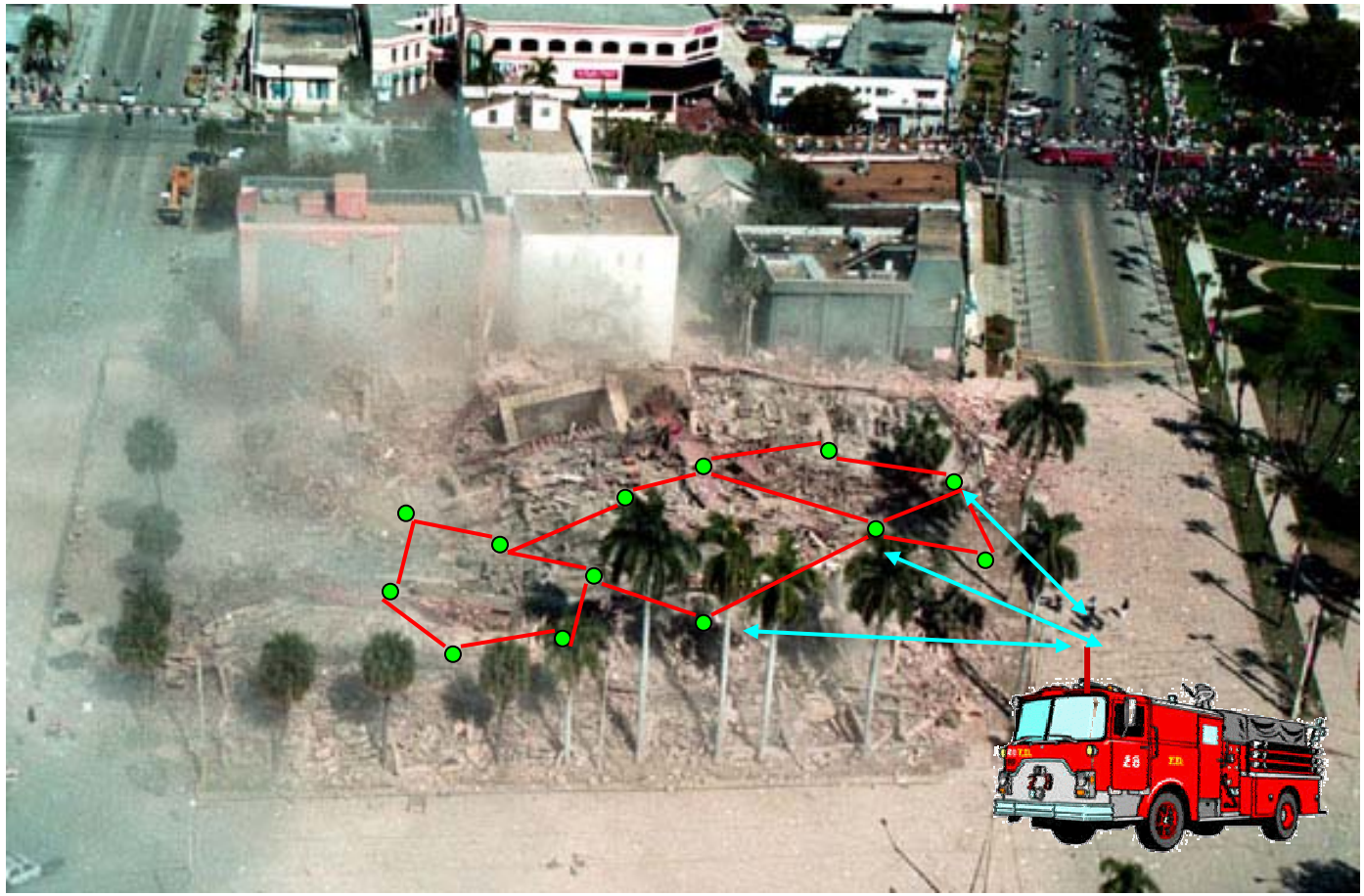
Sensor Nets for Search and Rescue



- **Active Sensor**

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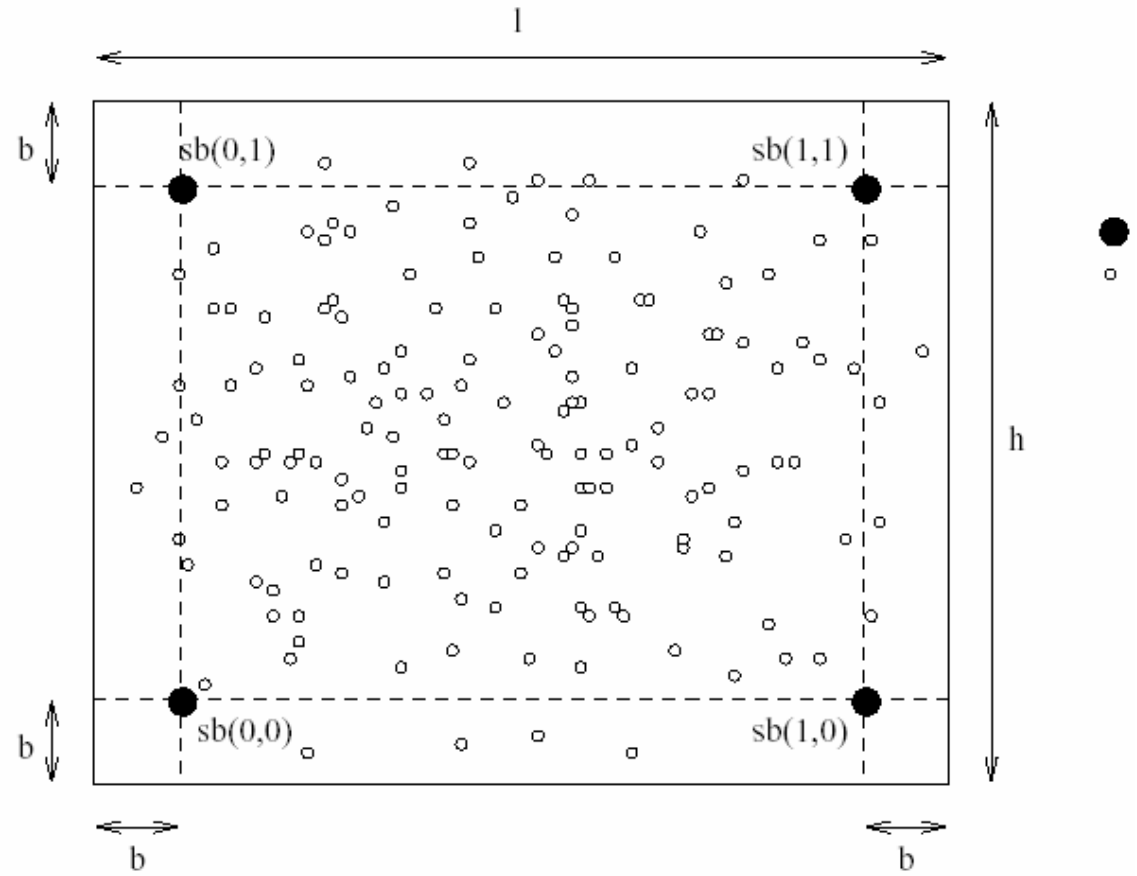
Research challenges in wireless sensor networks (1)

- **Operating system and software development**
  - Common approach:
    - ✓ "We have no problem, we have TinyOS"
  - TinyOS
    - ✓ Event-driven OS for sensor networks
    - ✓ Open-source project at UC Berkeley
    - ✓ Dedicated language NesC (C-like language)
    - ✓ Strong expertise is needed to develop sensor software
  - Is it what we want?
    - ✓ **Intelligence in operating system and framework** instead of **expertise of developers**
  - Alternatives:
    - ✓ Contiki [Sweden] Free BSD based OS
    - ✓ Java Iin The Small [Univ. Lille] JavaOS

Research challenges in wireless sensor networks (2)

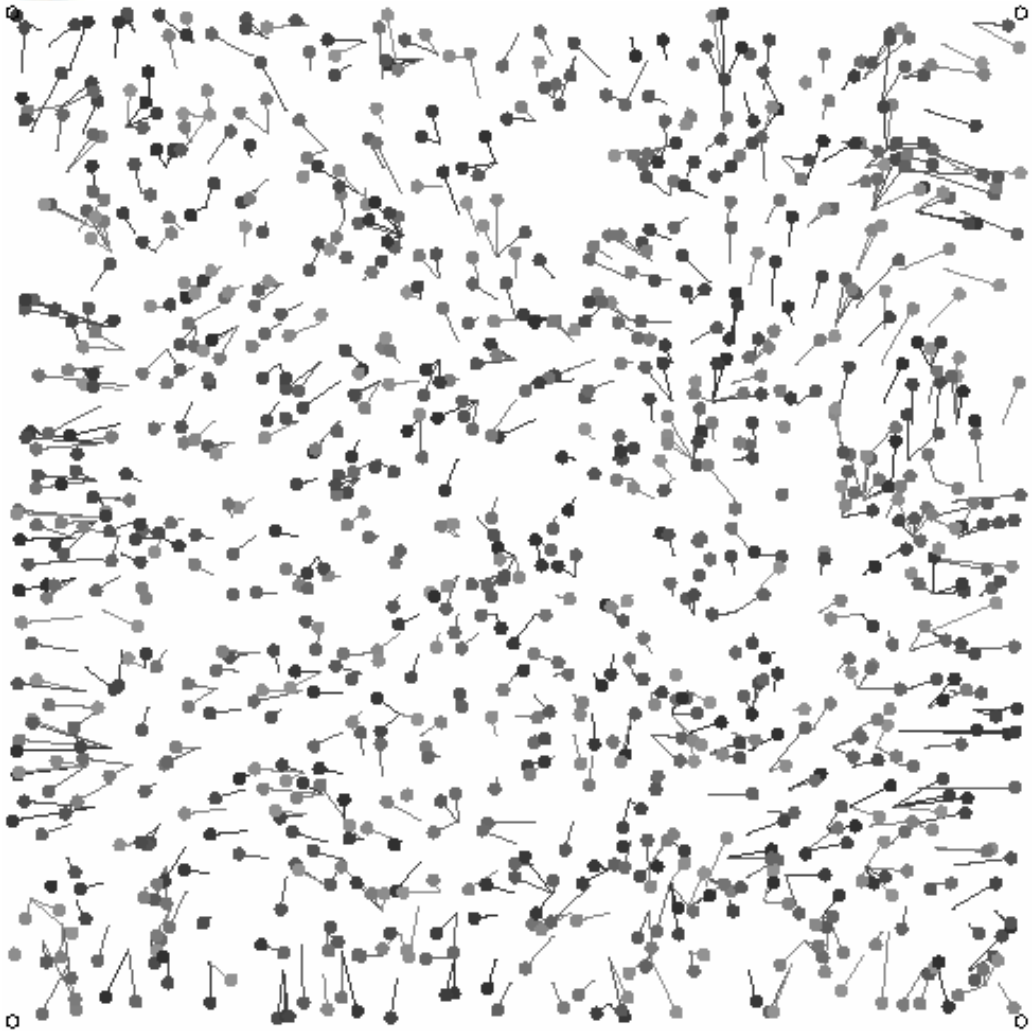
Localization and positioning

- Example of DV-hop triangulation:



- Base station (position known)
- Sensors

Positioning



- **Room = 10m x 10m**
- **Precision**
  - Hop = ± 43 cm
  - ν = ± 35 cm
  - RSS = ± 18 cm

Research challenges in wireless sensor networks (3)

Coverage and exposure problems

- Coverage problem
  - ✓ Quality of service (surveillance) that can be provided by a particular sensor network
  - ✓ Activity scheduling (nodes can sleep while preserving surveillance surveillance)
- Exposure problem
  - ✓ A measure of how well an object, moving on an arbitrary path, can be observed by the sensor network over a period of time

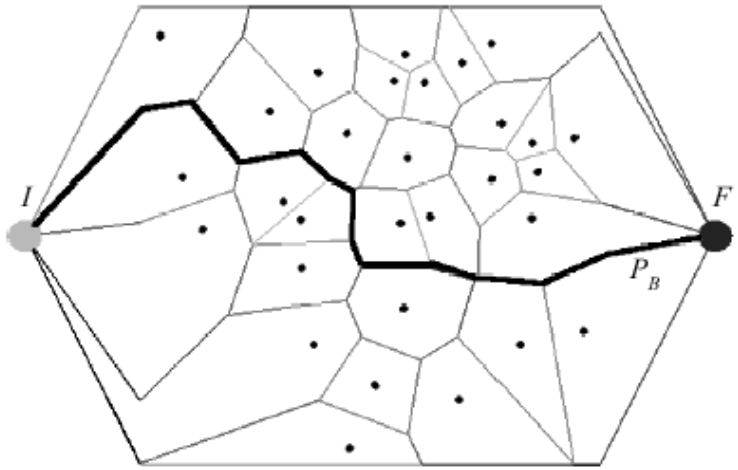
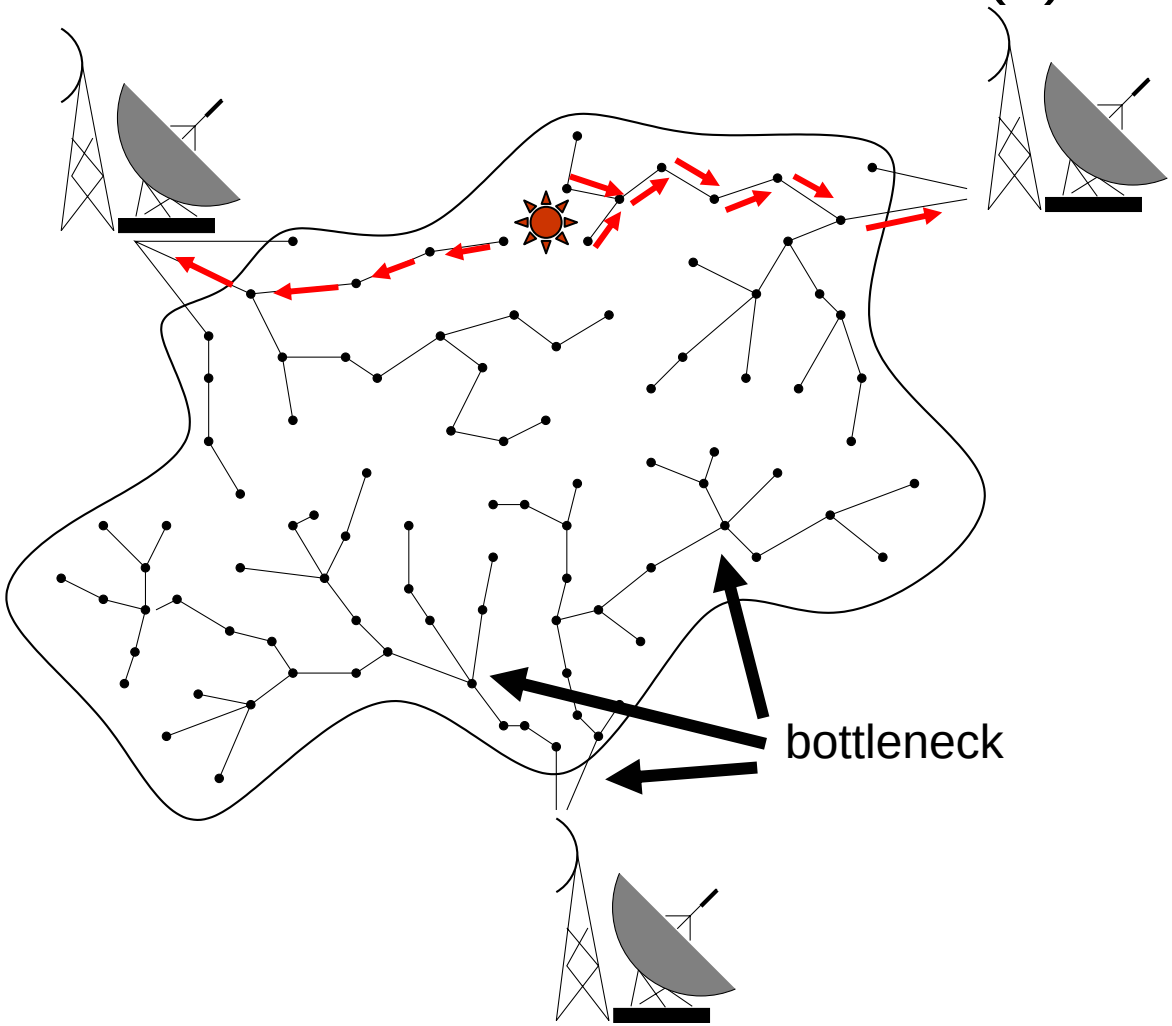


Figure 4 - Sensor Field With Weighted Voronoi

Figure 5 - Sensor Field With Weighted Delaunay Triangulation And Maximal Support Path (P_S)

Research challenges in wireless sensor networks (4)

- **Dissemination and data gathering**
  - Flooding is used to build gathering trees
  - Building *suitable* gathering trees is an open question
  - Flooding is a beaconless protocol but energy consuming
  - Data fusion is possible along transmission



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Conclusion

- **New networking paradigms and protocols**
  - Network = physical database
- **Self organization and localization**
  - Initialization
- **Energy efficient algorithms, protocols and systems**
  - MAC layer, Topology control, Transport layer, Component activity, etc…
- **Embedded operating systems**
  - Scalability, Real-time, Memory management, Component activity …
- **Security**
  - Of course…

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