

# Examples of WSN applications through EU-funded projects

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INSTITUT NATIONAL  
DE RECHERCHE  
EN INFORMATIQUE  
ET EN AUTOMATIQUE



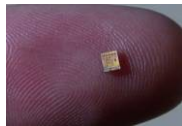
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# POPS research group

## « POPS System & Network »

- POPS = Tiny Targets = Constraint Hardware

Smart  
dusts



Smart  
labels



Smartcards



Sensors



Personal Digital  
Assistants



POPS=Portable Objects Proved to be Safe

- Technical characteristics:
  - From 8 to 32 bits Processors
  - 1 Kb of RAM, 64 Kb of E<sup>2</sup>PROM, 128Kb ROM
  - Limited electrical resources
  - Unsafe and untrusted deployment environment

*Usual « small devices »*



# Summary

## System and Networking for **P**ortable **O**bjects **P**roved to be **S**afe

*Common project-team INRIA, Univ. Lille & CNRS*

### Research project size

- 34 members: 3 Professors, 4 Associate professors., 2 research scientists + Eng./PhD/Postdocs

### Our ambition

- Thinking **POPS** as an **usual target** for general purpose **software** :
  - Hide the complexity of the exotic hardware and communication management
  - Provide usual API
  - “**Intelligence in system and framework** instead of **expertise of developers**”
  - Performance issue can be important

### Animation and implication in scientific community

- POPS is involved in the organization of 36 conferences, workshops, schools and scientific journals this year

### Relationship with companies

- Gemalto, SAP, Phillips, STm, Microsoft, Thales, Ericsson, Fiat
- Implied in the “Trade Industries cluster” in North of France

### Scientific production (international and 2007 only)

- 4 journals, 21 conferences, 2 book chapters



Collection Architecture, Applications, Service dirigée par Michel Diaz

# Réseaux de capteurs

*théorie et modélisation*

Eric Fleury  
David Simplot-Ryl



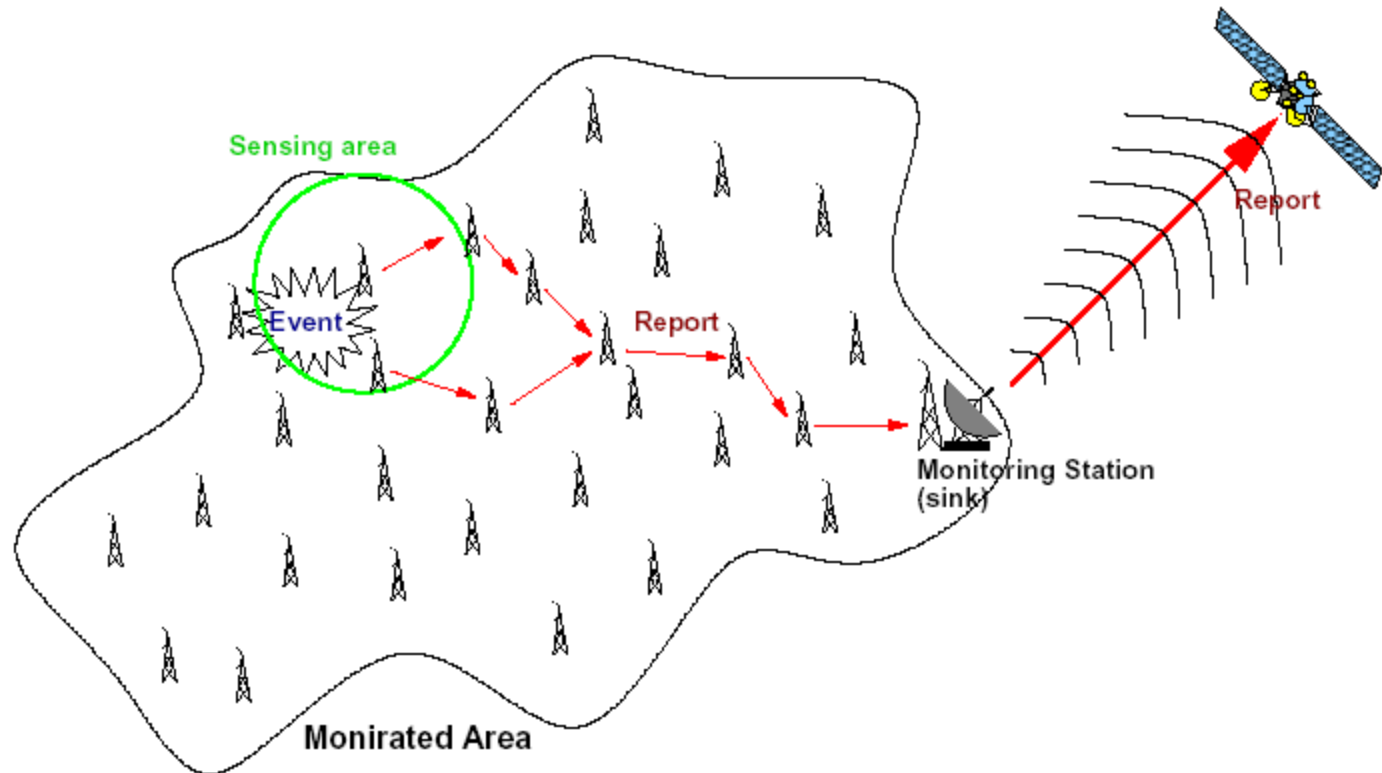
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 **INRIA**

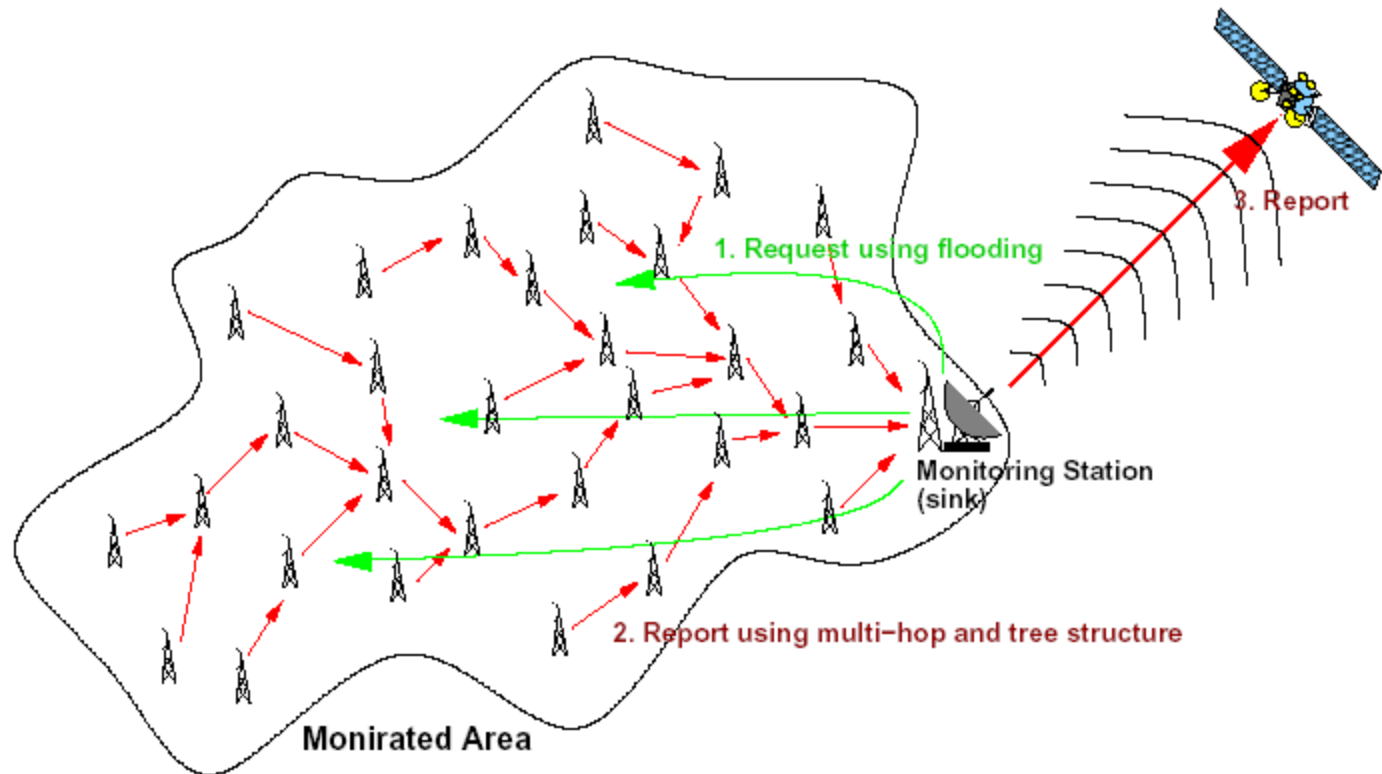
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# WSN : from theory...

# Event-driven model



# On-demand model



# Sensor Nets for Search and Rescue



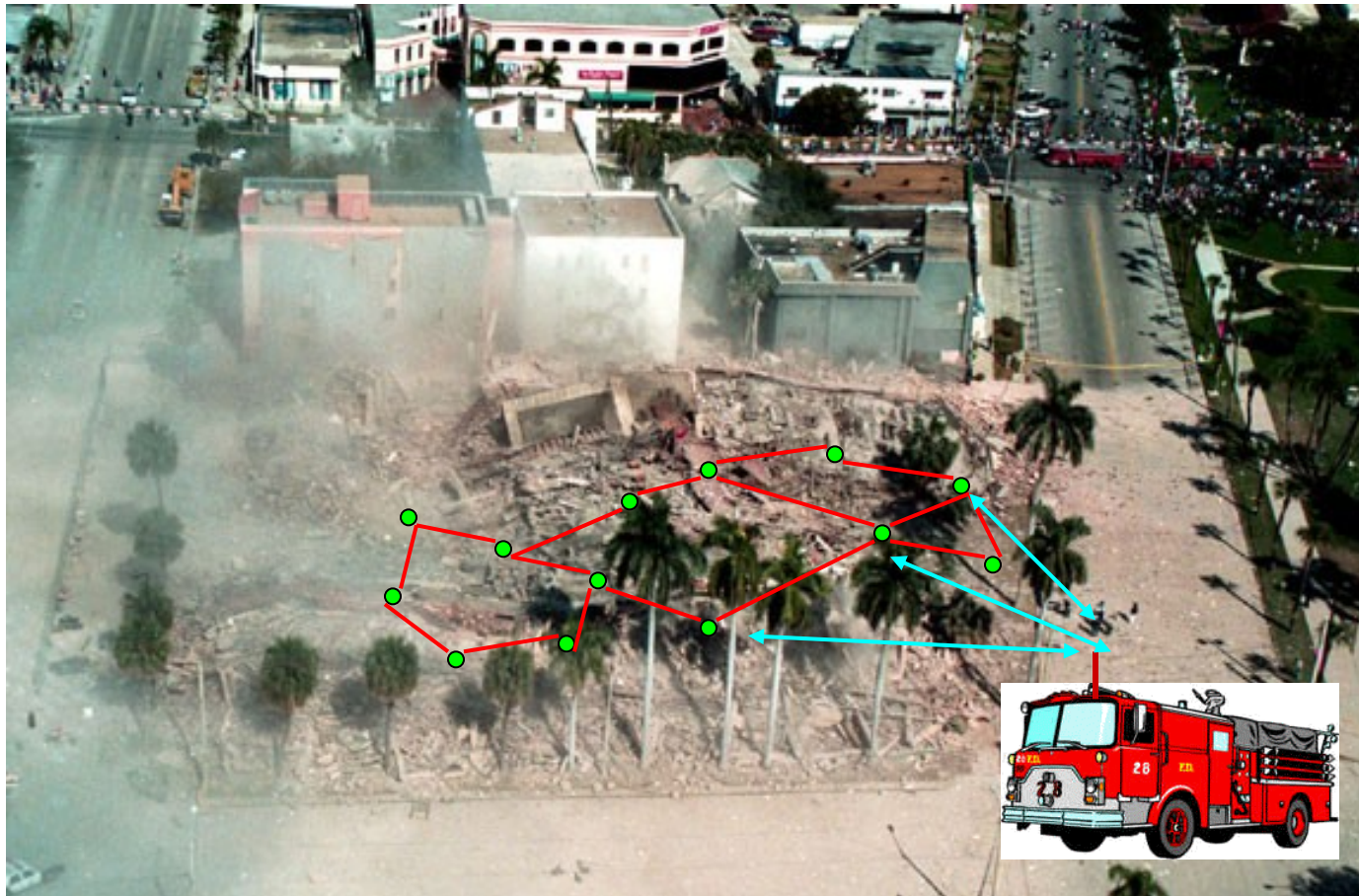
- Inactive Sensor



# Sensor Nets for Search and Rescue

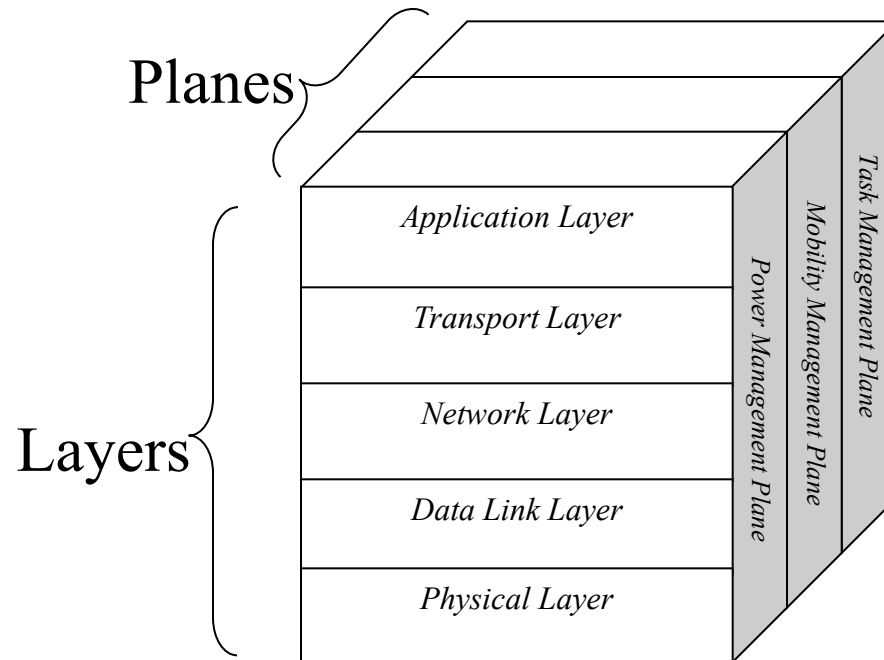


# Sensor Nets for Search and Rescue



- Active Sensor

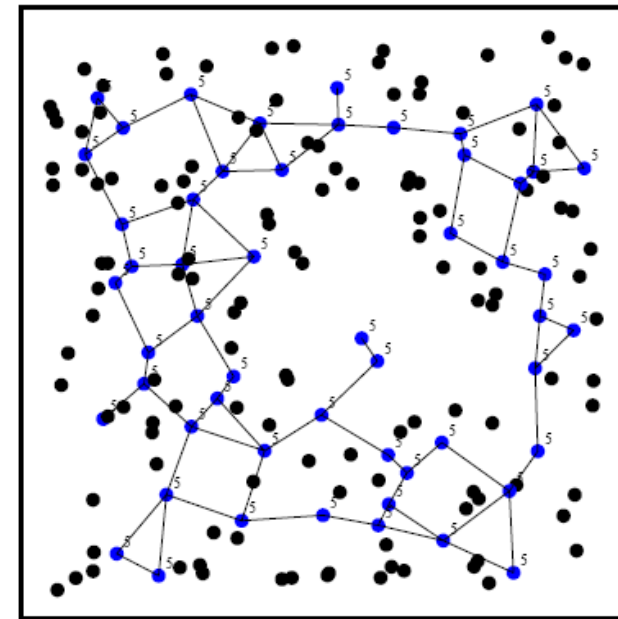
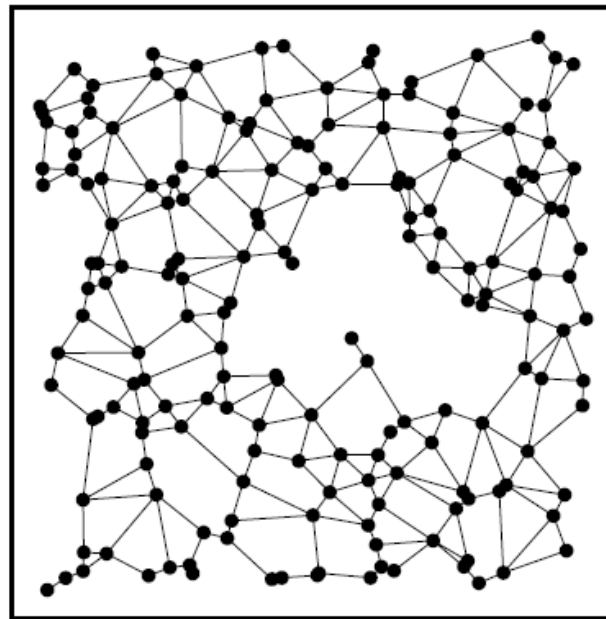
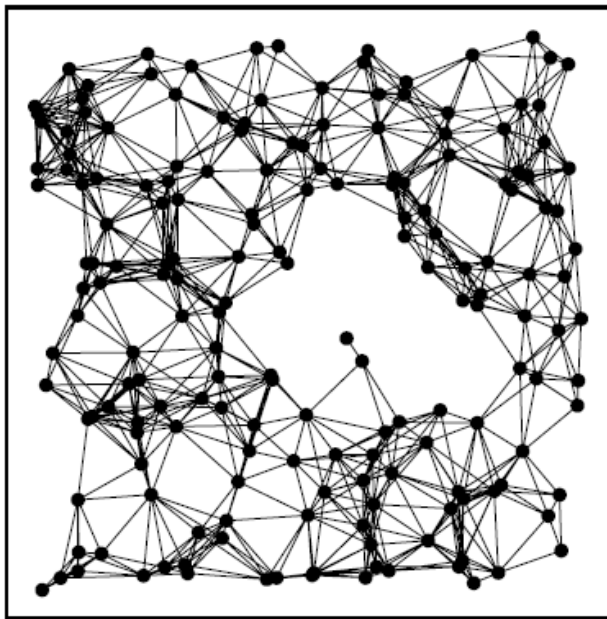
# Protocol Stack



\* I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, E. Cayirci, "Wireless sensor networks: a survey", *Computer Networks*, 38 (2002), pp. 393-422.



# GG over CDS



... to real applications

# Sensor applications



## WASP Project

## Wirelessly Accessible

## Sensor Populations



**Philips** Research Eindhoven,  
Philips Forschung Laboratorium,  
IMEC, CSEM, TU/e, **Microsoft**  
Aachen, Health Telematic Network,  
Fraunhofer IIS, Fokus, IGD,  
Wageningen UR, Imperial College  
London, **STMicroelectronics**,  
**INRIA**, Ecole Polytechnique  
Federale Lausanne, Cefriel, Centro  
Ricerche **Fiat**, Malaerdalen  
University, RWTH Aachen, **SAP**,  
Univ of Paderborn

<http://www.wasp-project.org/>



# Sensor applications

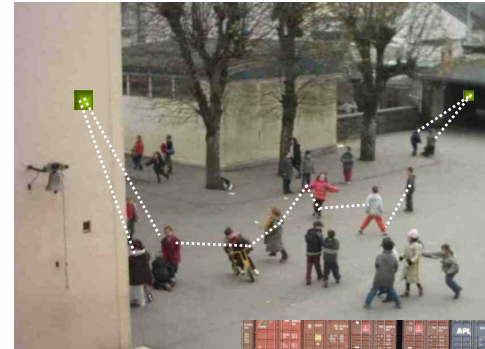


SVP Project

Surveiller et Prévenir

*Survey and prevent*

CEA, INRIA, Institut Maupertuis,  
Aphycare, LIP6, M2S, **Thales**,  
ANACT



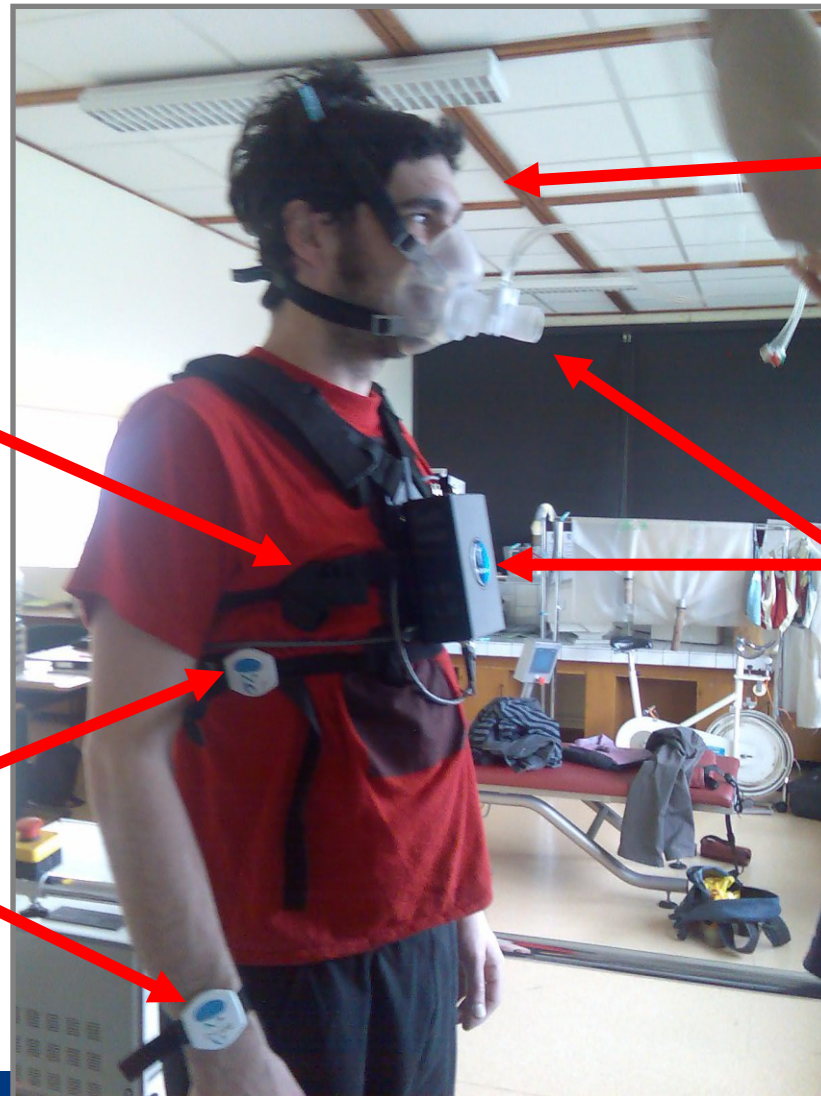
<http://surveiller-prevenir.irisa.fr/>



# Dispositif expérimental

Ceinture POLAR pour la mesure ambulatoire de la FC

5 capteurs Séréo'Z sans fil



Un Anthony motivé par la recherche !

VO2000 : Mesure ambulatoire des échanges gazeux

*Tapis déroulant  
Vélo à effort paramétrable  
Sac à dos chargé*

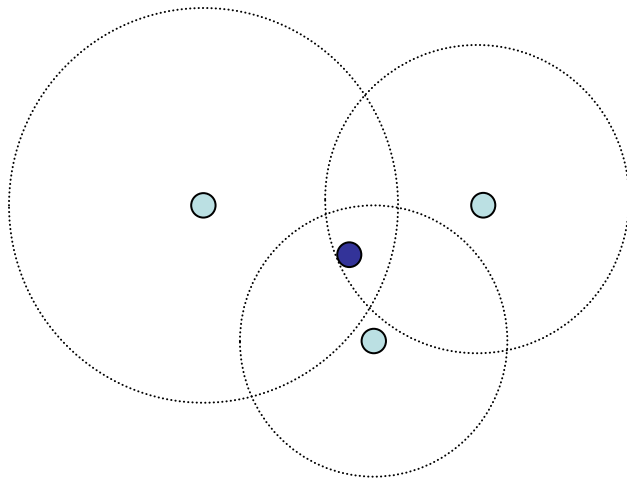


# Focus on localization

# Location Positioning

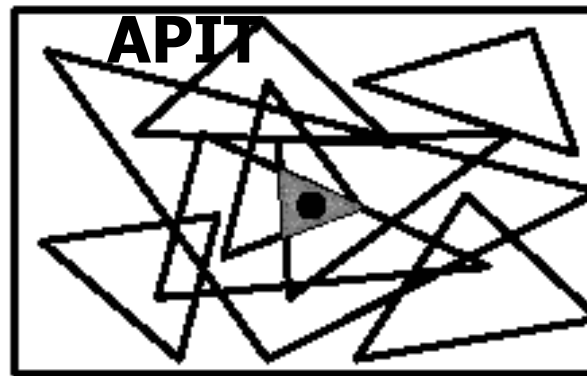
[Folklore, Calinescu 2003, Simplot-Ryl 2003, Ermel 2004]

## Centroid

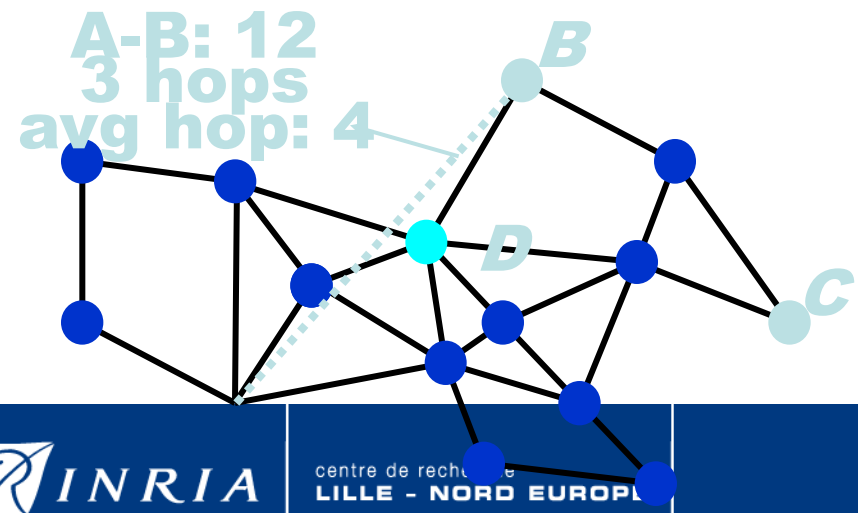


$$(X_{est}, Y_{est}) = \left( \frac{X_1 + \dots + X_N}{N}, \frac{Y_1 + \dots + Y_N}{N} \right)$$

## Area-based



## DV-hop



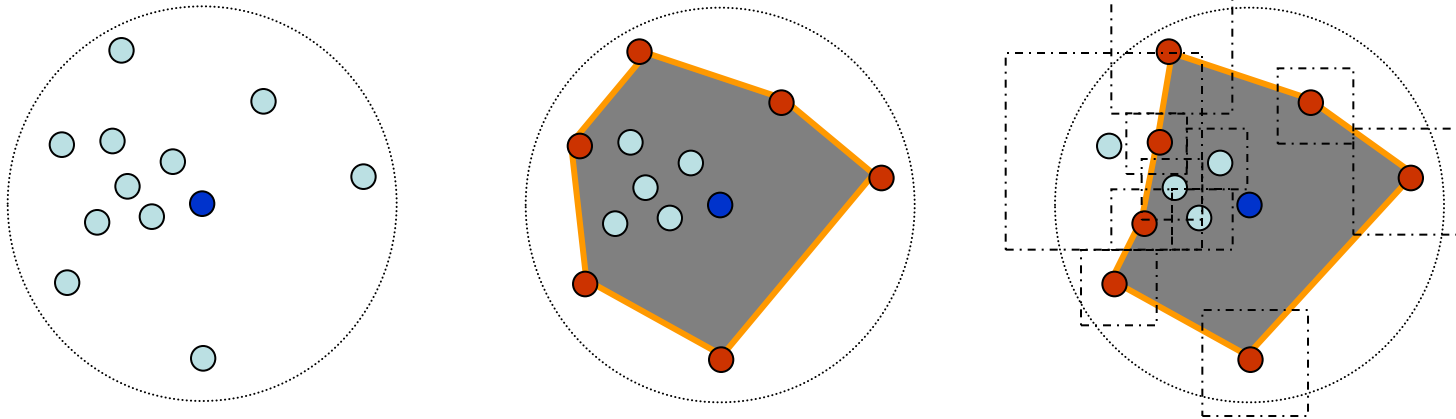
# Centroid improvements

[Ermel et al. 2004]

Idea: All nodes are not useful to compute position

Select nodes on convex hull and calculates barycentre for position estimation

An error estimation is also computed from error rate provided by neighbors



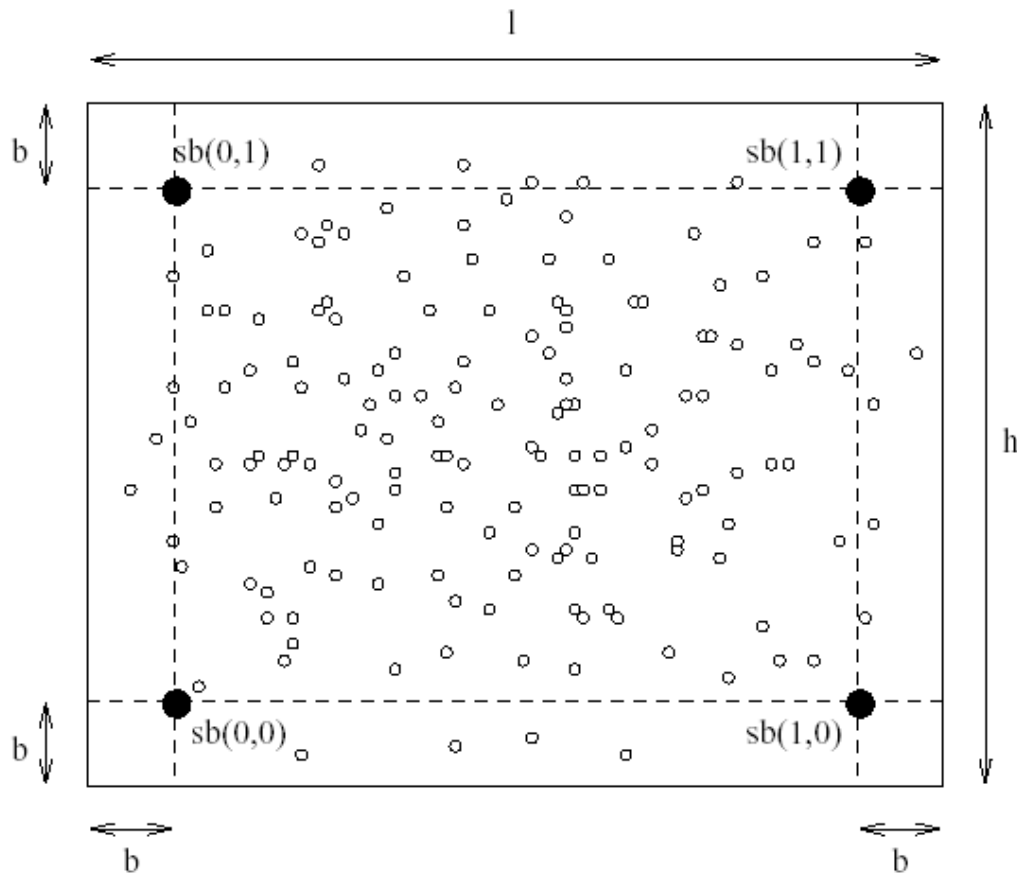
Improvement of 30% on position error



# DV-hop improvement

[Calinescu 2003, Simplot-Ryl 2003]

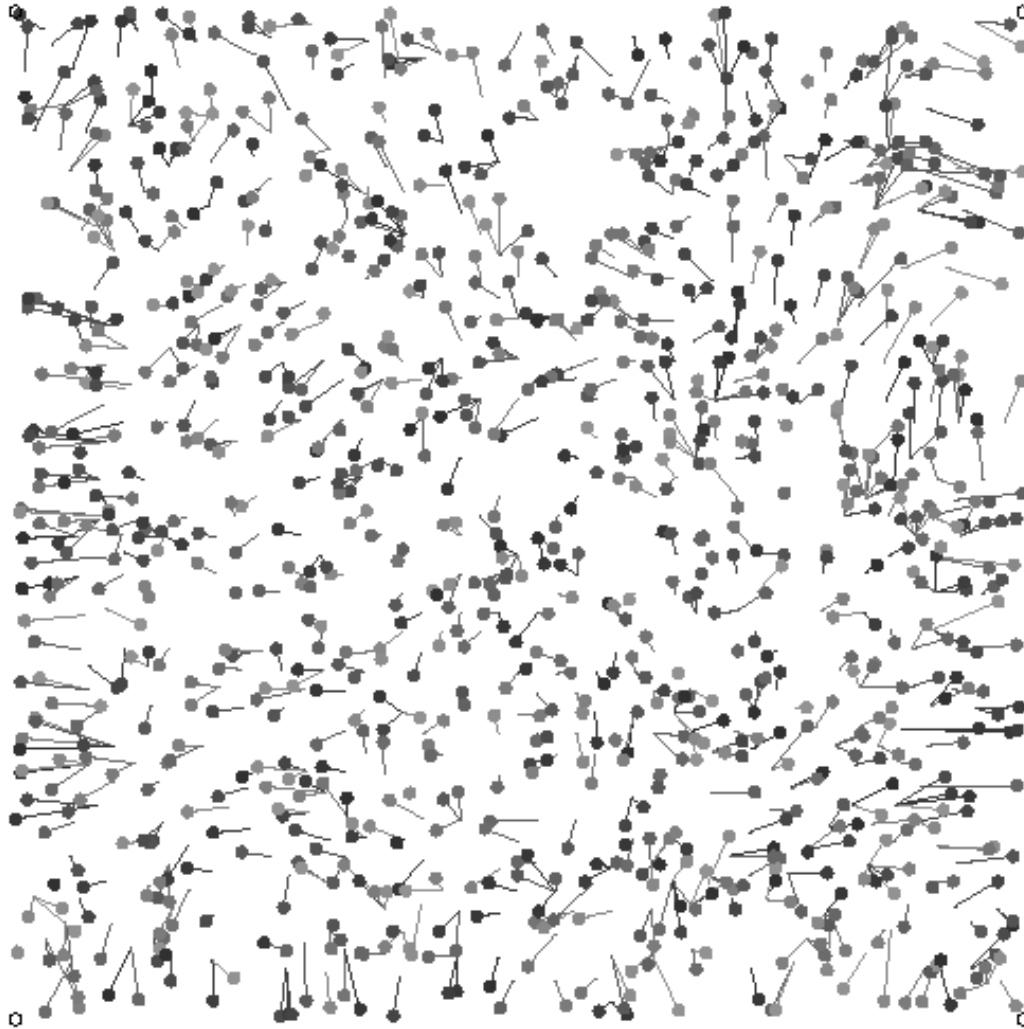
Principle of DV-hop triangulation:



- Base station (position known)
- Sensors



## DV-hop improvement (4)



Room = 10m x 10m

### Precision

- Hop =  $\pm 43$  cm
- $v$  =  $\pm 35$  cm
- RSS =  $\pm 18$  cm



# Use of RFID tags to add contextual/location information

## Take advantage of passive tags

- Once powered, the tag emits
- The reader listen channel and can inform a centralized system of the location of the “tagged” item



## Problems:

- Power and hear the tag whatever the tag orientation
- Privacy
- How to combine this solution with other techniques?

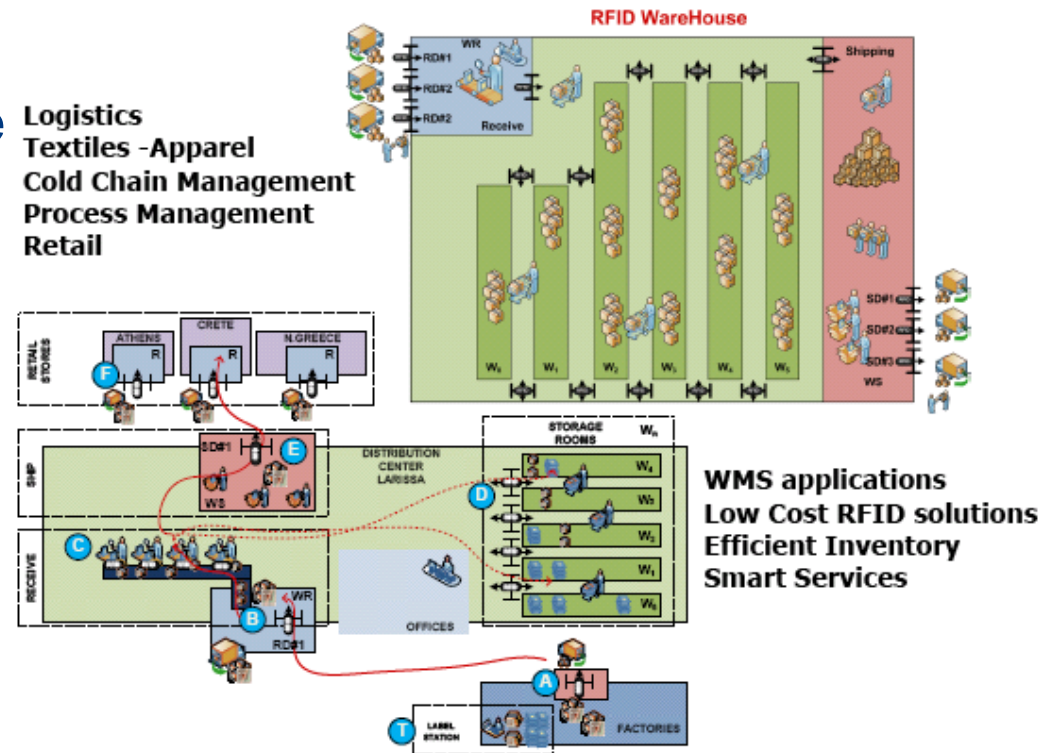


# RFID middleware

## ASPIRE

Programmable Open-Source  
RFID Middleware for SME

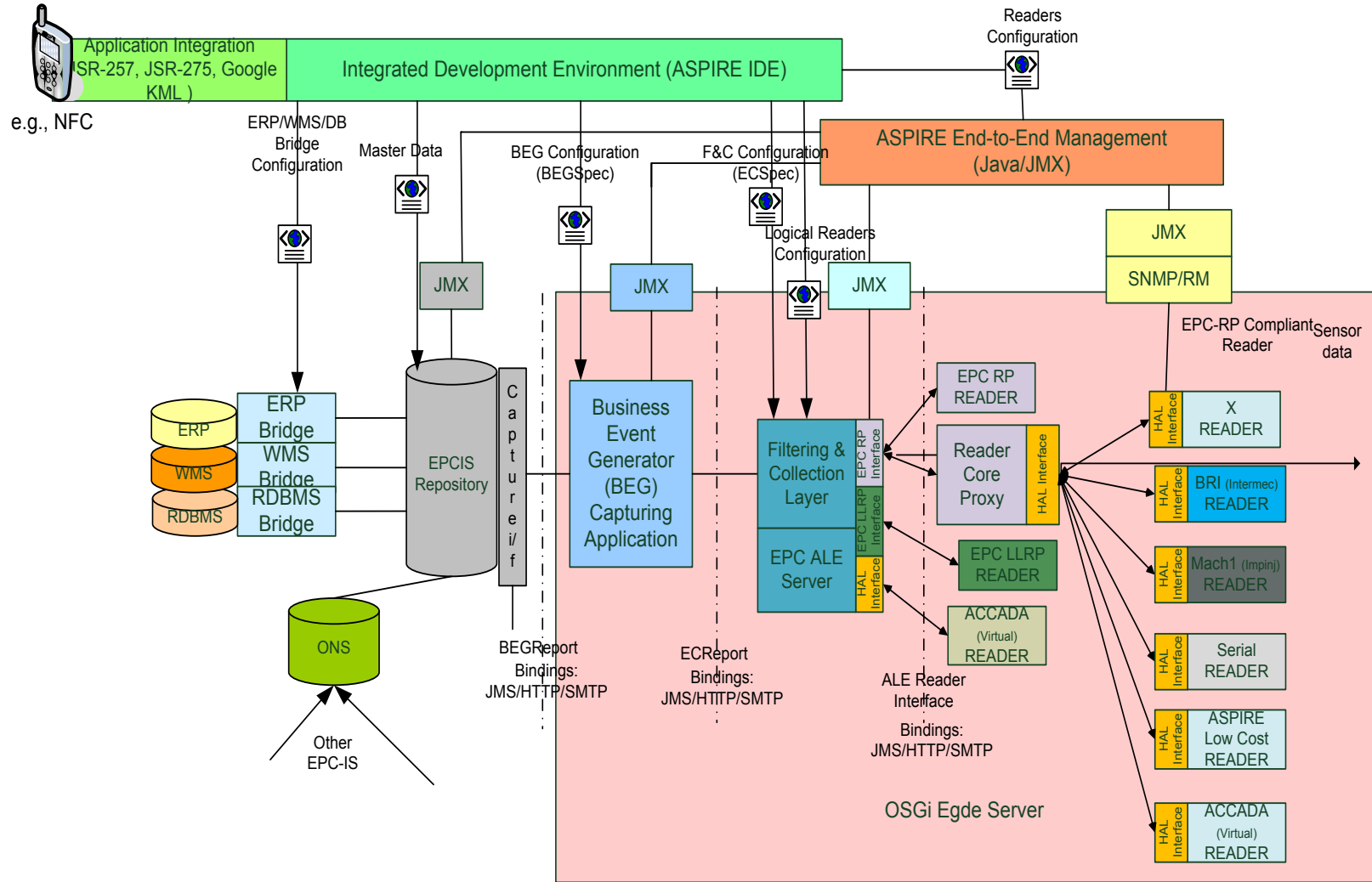
Aalborg Univ., Univ. J.  
Fournier, OSI, UEAPME,  
INRIA, Melexis, Sens@p,  
Instituto de telephonicacoes,  
Pôle traçabilité, Athens  
Information Technology



<http://www.fp7-aspire.eu/>



# AspireRfid Implements the ASPIRE Architecture





# RFID Suite *branch*

## Web2.0 User console – Object Geo Tracking

RFID Middleware - Windows Internet Explorer

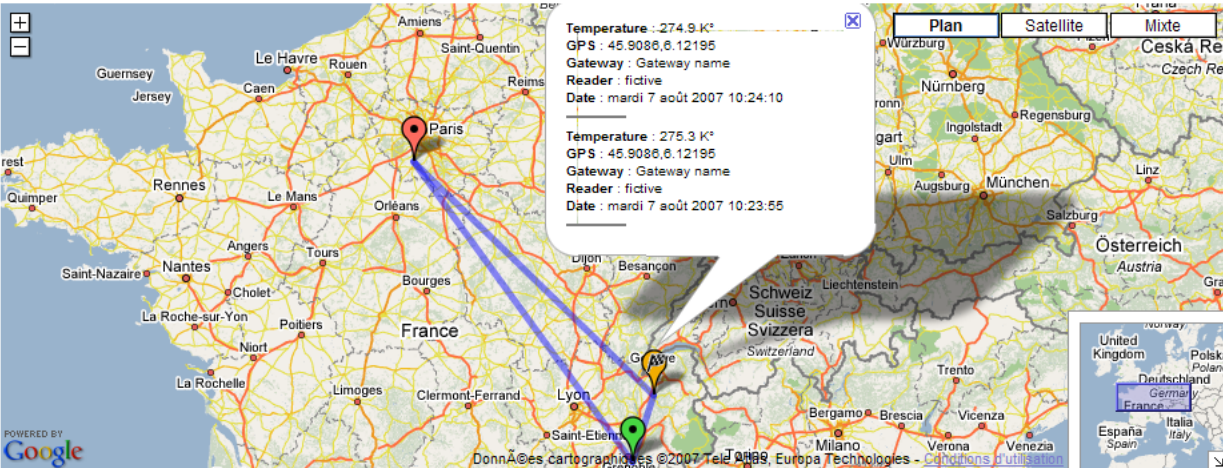
http://localhost:9000/epcis/fr.imag.adele.rfid.gwt.IndexModule/IndexModule.html

admin@

Tag > Track on map

Tag :  Valid Input helper Get general information

Tracking Complementary information



Information :

- ✓ Path
- ✓ Marker
- ✗ Partner information

Display Focus Clear map

Legend :

- Start
- Intermediate
- Finish

Pos	Gateway	Reader	Date
1	Gateway name	fictive	mardi 7 août 2007 10:25:34
2	Gateway name	fictive	mardi 7 août 2007 10:25:01
3	Gateway name	fictive	mardi 7 août 2007 10:24:40
4	Gateway name	fictive	mardi 7 août 2007 10:24:10
5	Gateway name	fictive	mardi 7 août 2007 10:23:55
6	Gateway name	fictive	mardi 7 août 2007 10:23:49

POWERED BY Google

Données cartographiques ©2007 Tele Atlas, Europa Technologies - Contributions à utilisation

Intranet local 100%

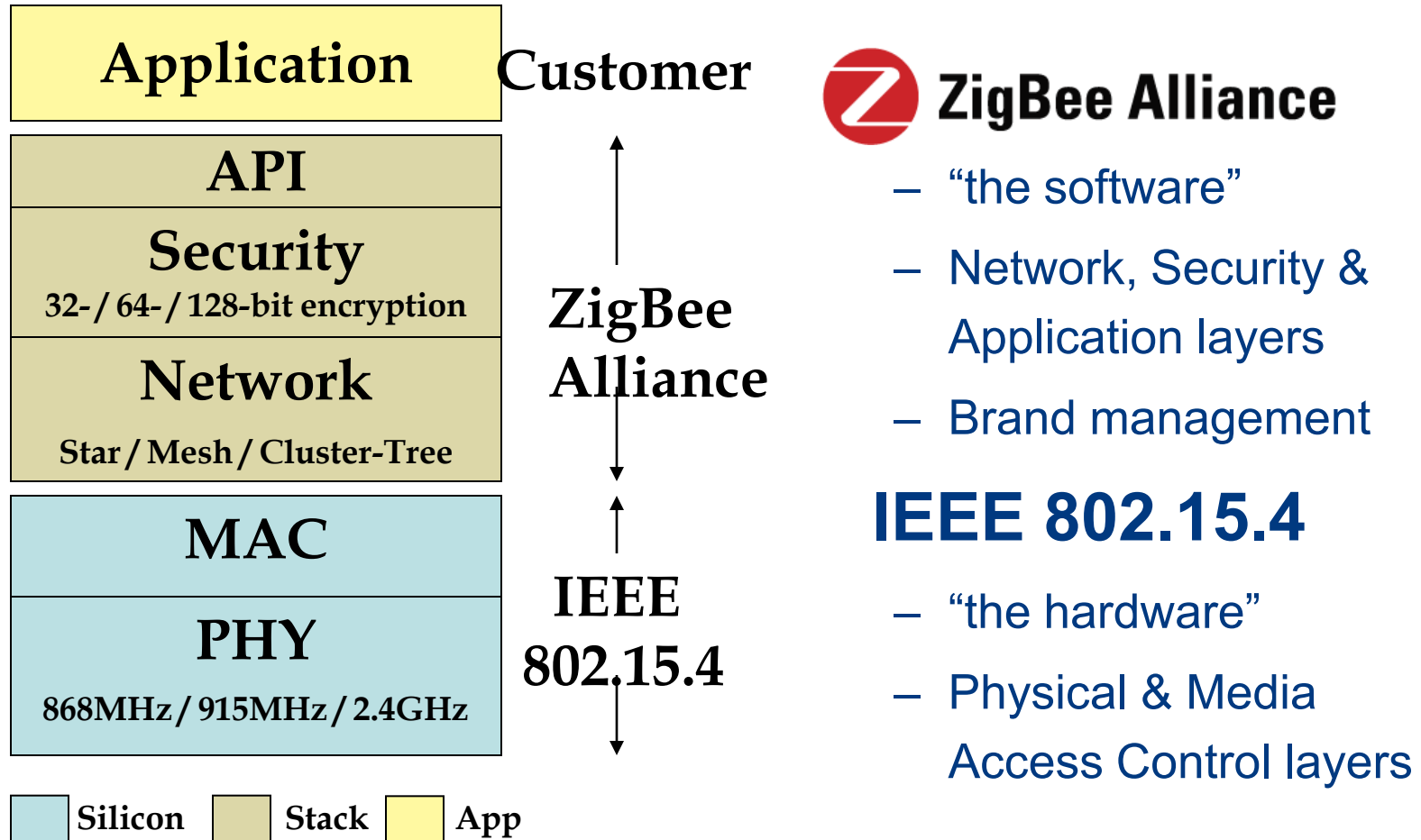
# Learned lessons

# Conclusion

Technology is mature for real world applications



# IEEE 802.15.4 & ZigBee In Context



Source: [http://www.zigbee.org/resources/documents/IWAS\\_presentation\\_Mar04\\_Designing\\_with\\_802154\\_and\\_zigbee.ppt](http://www.zigbee.org/resources/documents/IWAS_presentation_Mar04_Designing_with_802154_and_zigbee.ppt)

# Conclusion

Technology is mature for real world applications

Research activities are focusing on improvement in real world conditions

- “beyond unit disk graph”
- Software reliability



# SensLab : very large open wireless sensor network testbed



INRIA, Thales, LIP6, LSIIT

# Conclusion

Technology is mature for real world applications

Research activities are focusing on improvement in real world conditions

Environment monitoring will not be the core of the “big business”



# Smart buildings: from WSN to SANET





# Conclusion

Technology is mature for real world applications

Research activities are focusing on improvement in real world conditions (“beyond unit disk graph”)

Environment monitoring will not be the core of the “big business”

Localization/positioning (indoor and outdoor) will be a key feature for new services



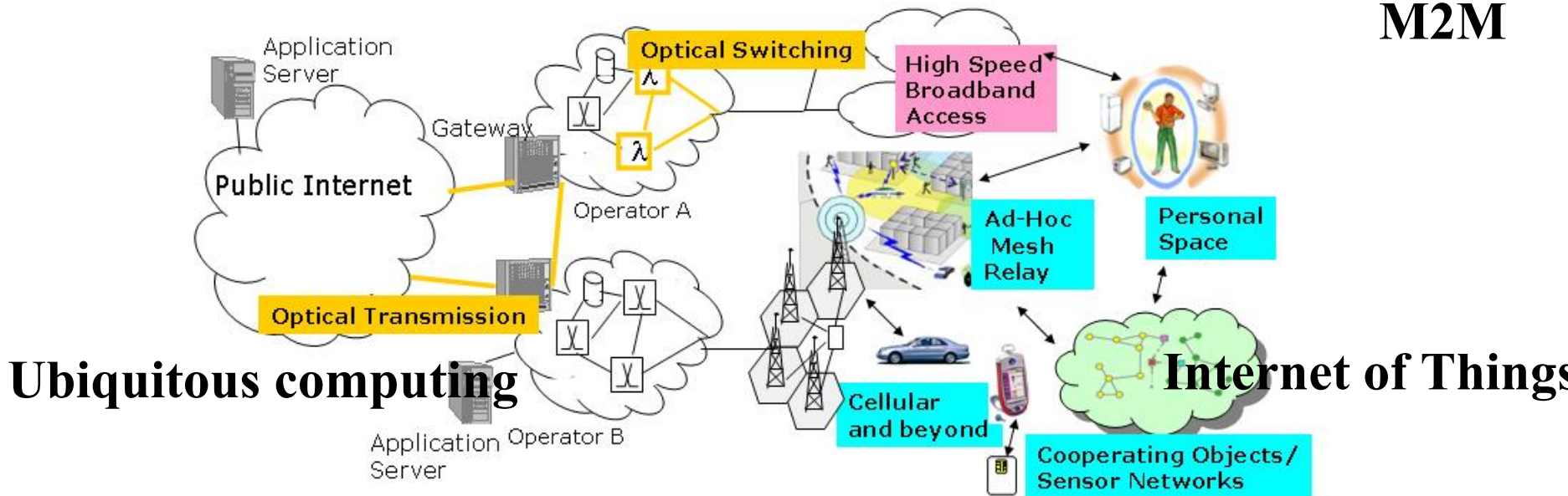
# Future Internet

<http://www.future-internet.eu/>

Goal: Internet architecture designed for future mobile and fixed access

## Ambient Intelligence

M2M



## Real world Internet

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