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# Some Examples of Wireless Sensor Networks at Philips Research

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# WSN interest in Philips

- Medical Systems
- Domestic Appliances
- Consumer electronics
- Lighting
- Semiconductors
- Research

# Overview

- Health, Body projects
- Building projects
- Hardware aspects

- European projects

- Personal interests

# Acknowledgements

| | |
|---|---|
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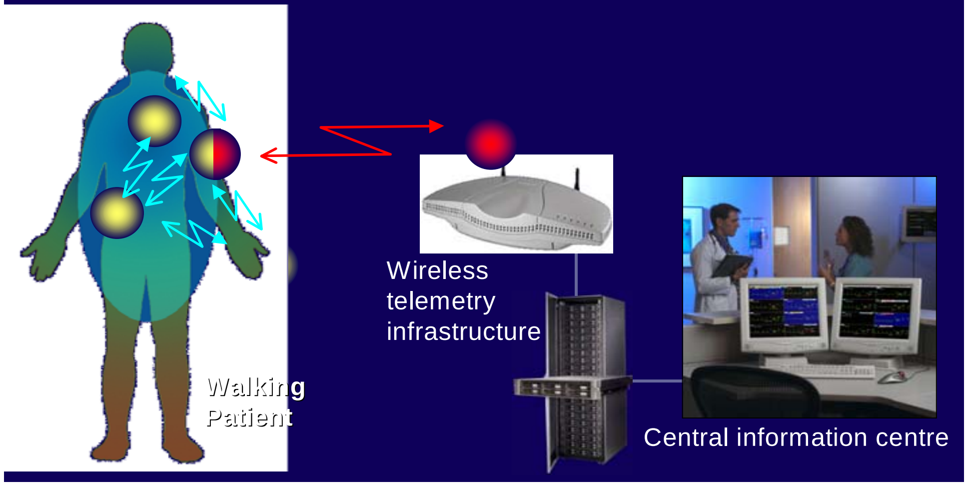
# Wireless BAN

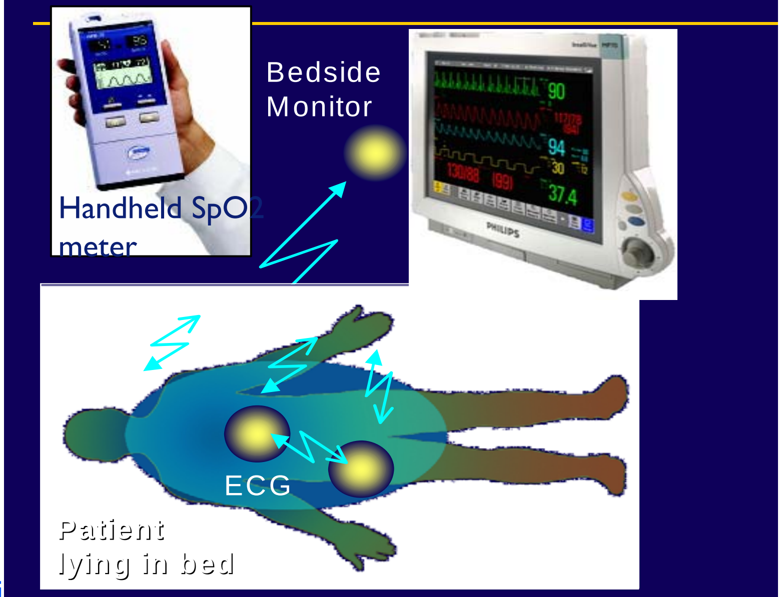
# Healthcare Scenarios

**Vital Body Signs collection**

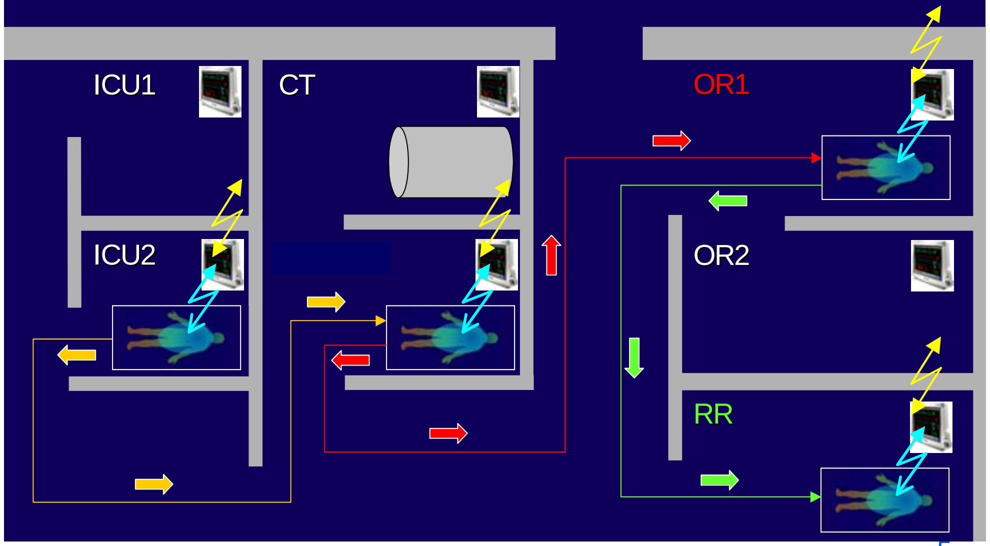
## Ambulatory Monitoring




## At Patient's Bedside




## Patient Transport



# Observations in PMS

Wireless enabled applications are and will  not be served by a single "one size fits all" technology

Many of today's wireless application are standalone and not interoperable with other applications

Hospitals prefer shared, multi-purpose networks

The industry's drive to migrate to a catalogue of **specific** (eg. range, bandwidth) but **interoperable** set of solutions will ultimately yield a much more **integrated** Wireless Healthcare application landscape and boost wireless connectivity deployment

**The future is for commodity technology with medical grade capabilities**

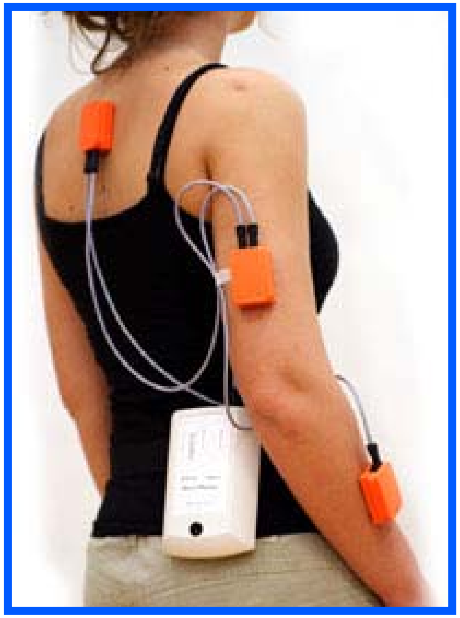
- predictable (real-time) performance
- dependable, reliable, fault tolerant
- fast network discovery/association, hot plug & play, auto recovery
- energy efficient (incl light weight protocols)
- support security & privacy requirements
- shared spectrum coexistence

# HOST/ULTRA

## Rehabilitation of stroke patients

– Motor rehabilitation of arms
– Equip patient with inertial sensors to measure movement of limbs
– Check if exercises are performed correctly

→ One therapist can treat multiple patients simultaneously

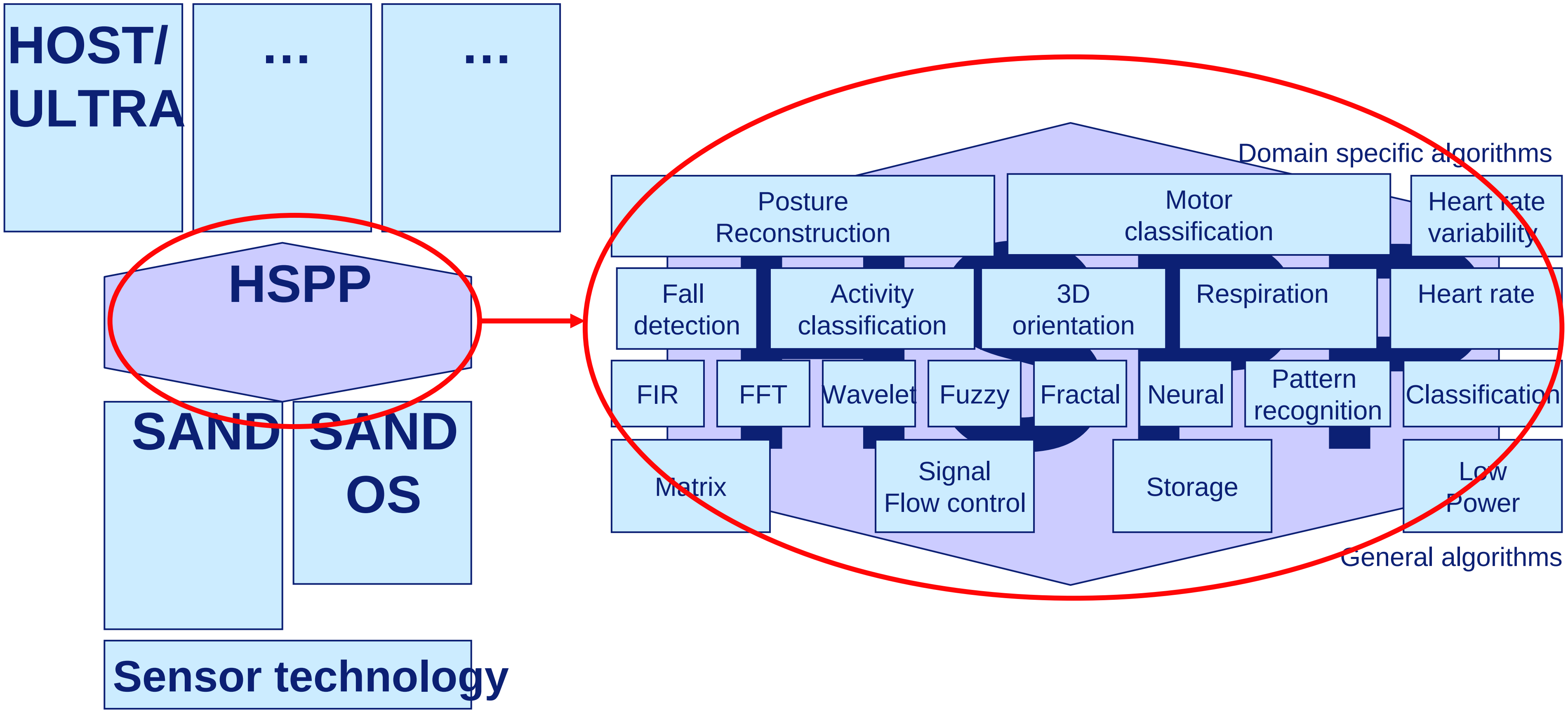


## HSPP's task

– Perform posture reconstruction from raw sensor data
  – accelerometers
  – magnetometers
  – (gyros??)

– Perform clinical trial in 2006Q4 ⇒ 60 nodes + 10 base stations

# Healthcare Signal Processing Platform



# Security Research Challenges

**Technical Restrictions**

Low resource devices
- Energy:processing and communication
- Memory
- Low bandwidth

**Legal Requirements**

HIPAA
European Directive 95/46

**Operational Requirements**

Mobility
Scalability
Ad hoc networks
Transparent Security
Hospital Infrastructure

**Design of resource efficient key management schemes**

**Design of a key management architecture that allows complying with legal laws, i.e.,**

**- key setup design for WSNs,**

**- node revocation,**

**- support of basic security services (node auth, etc)**

**- High overall security (resiliency)**

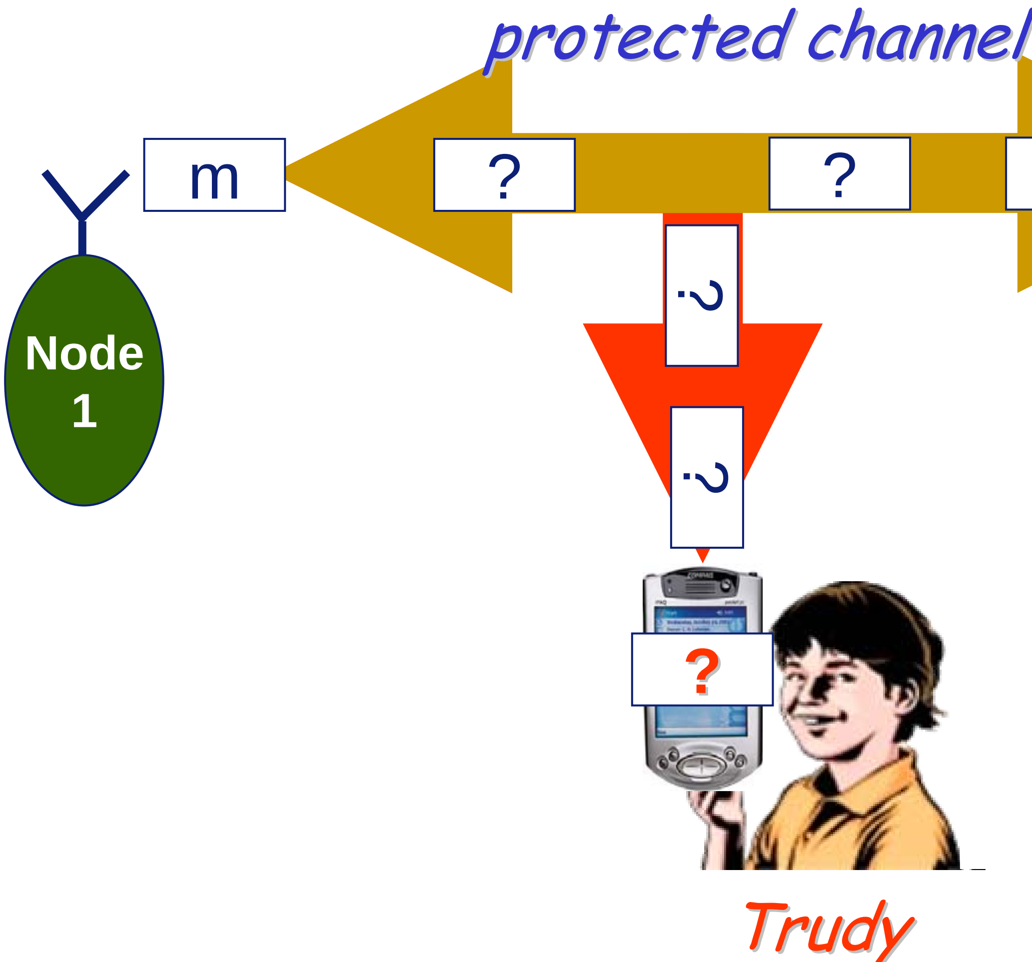
**Design of a key management infrastructure:**

**- feasible for ad hoc networks,**

**- requiring low user interaction, and**

**- matching with hospital hierarchical infrastructure.**

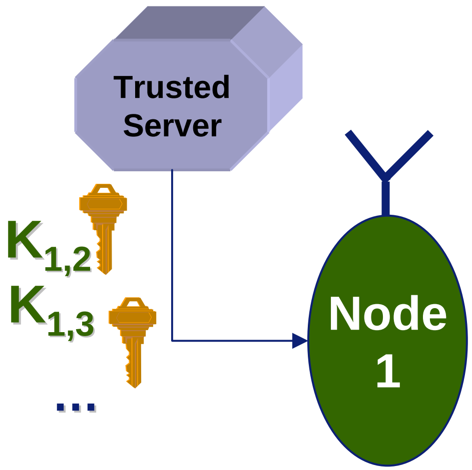
# (Some) Security Objectives/Services




- Authentication of nodes and messages
- Message confidentiality and integrity
- …

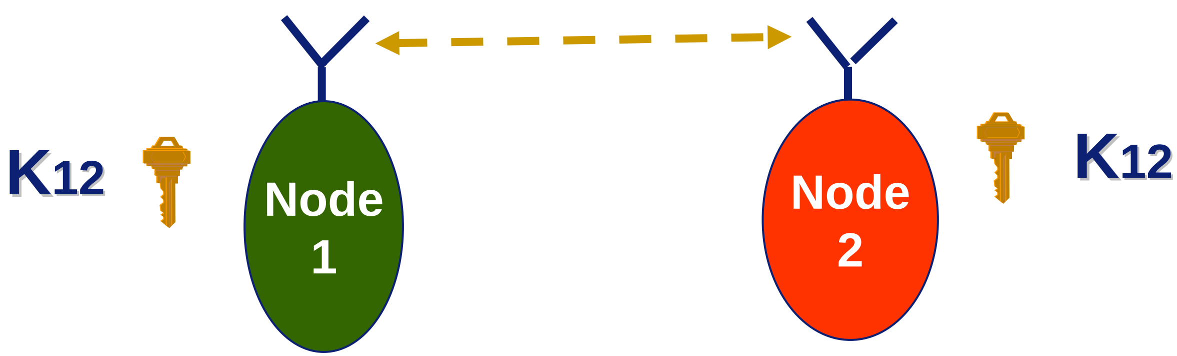
# Key Pre-distribution Scheme (KPS)

1- Provision of pairwise symmetric keys




The nodes *a priori* get all the keys for the communications they may establish in the future

2- Key Usage



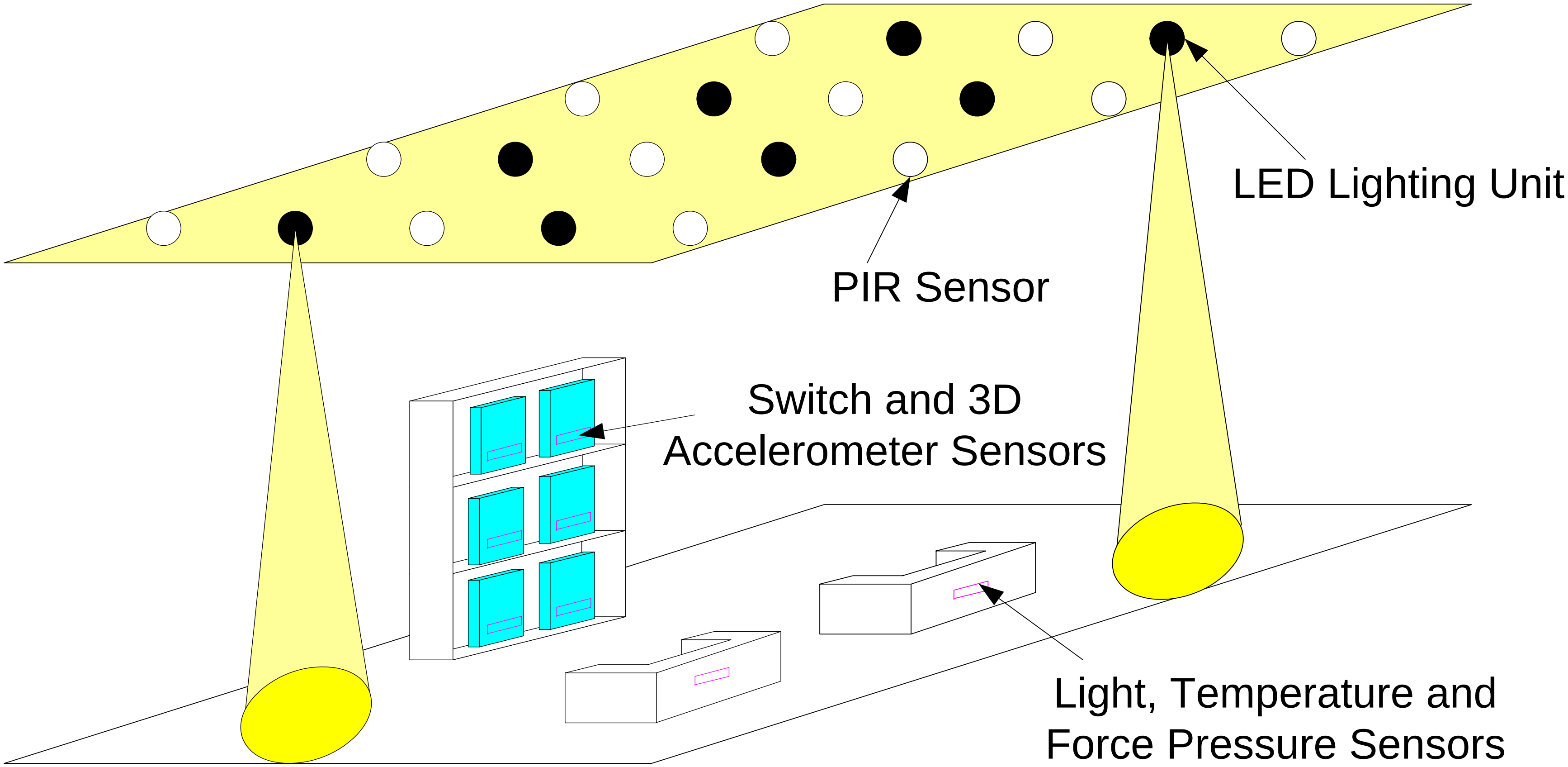

- No need for server to be online
-Symmetric key crypto is computationally efficient

# Deterministic Pairwise Key Pre-Distribution

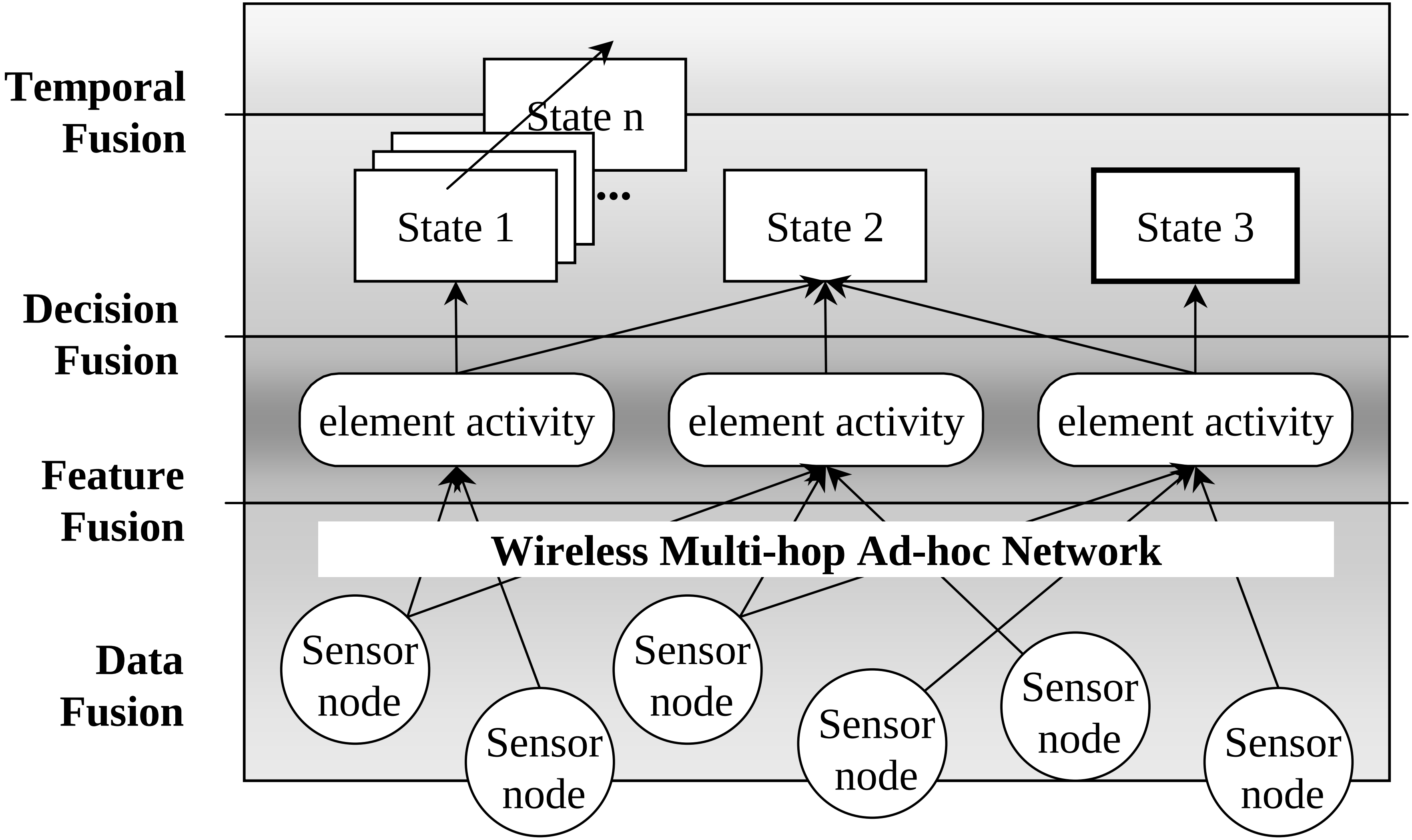
- Support for direct key establishment
(for independence of WSN size and misbehaving nodes)
- Suitable for 4 or 8 MHz 8-bit CPU
- DPKPS has energy cost 2000 times lower than a handshake using public key RSA-1024
- Scalability: key material for up to 2 million of devices in 2kBytes
- Computation of almost 87000 pairwise keys with just a 5% of the energy of a button battery of 30 mAh, which is equivalent to generate two pairwise keys per minute for one month.

# Building, lighting

# Shop Lighting application (SAINT project)



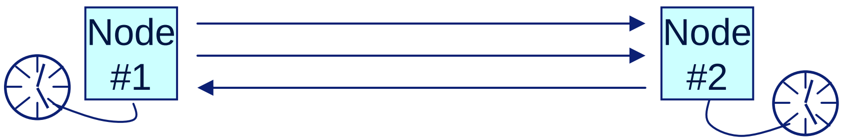
# Human activity recognition



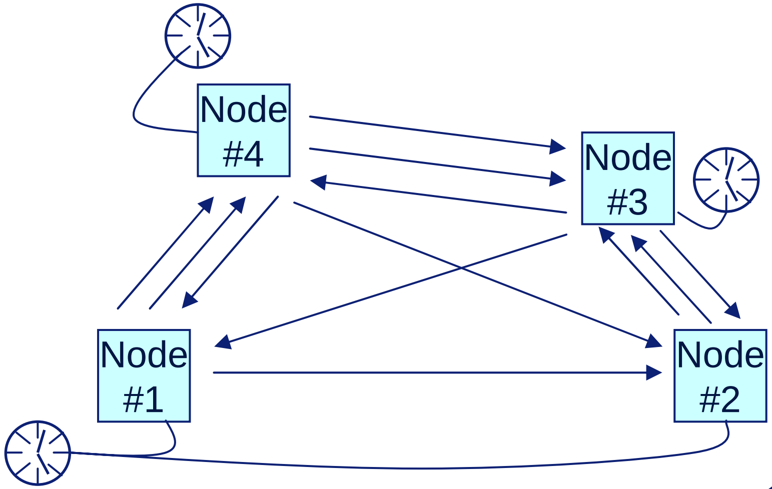
# Time-of-Flight measurement

- Measuring distances between sensor nodes can enable:
  improved routing algorithms, tracking applications, automatic set-up
- Distance can be measured by measuring the Time-of-Flight of signals

- Two sensor nodes without common sense of time can measure the distance between them by exchanging three RF messages




- In many practical sensor networks some pairs of nodes share a sense of time and others don't



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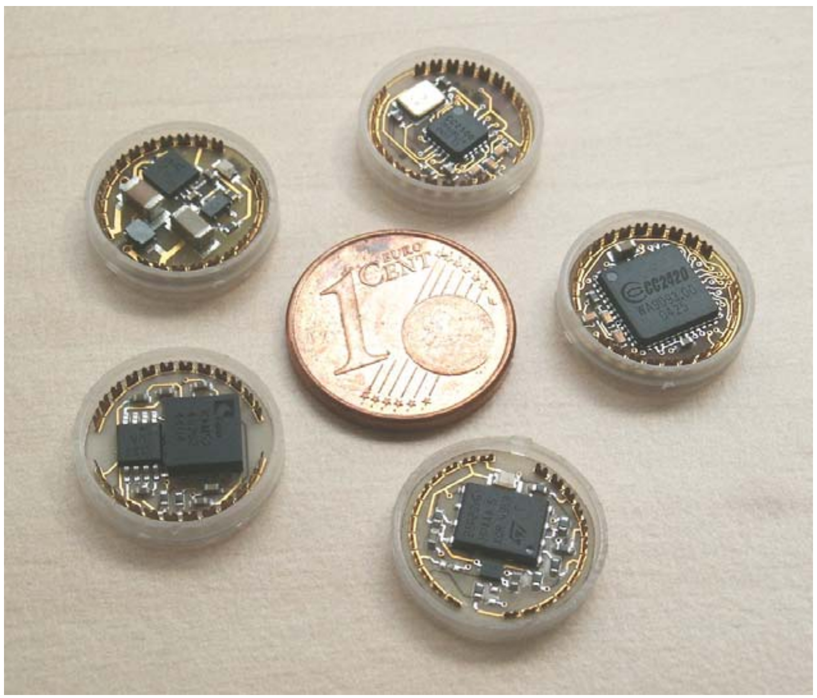
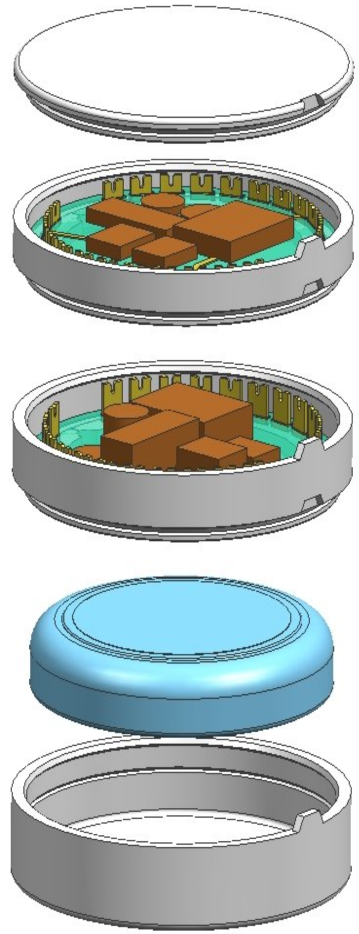
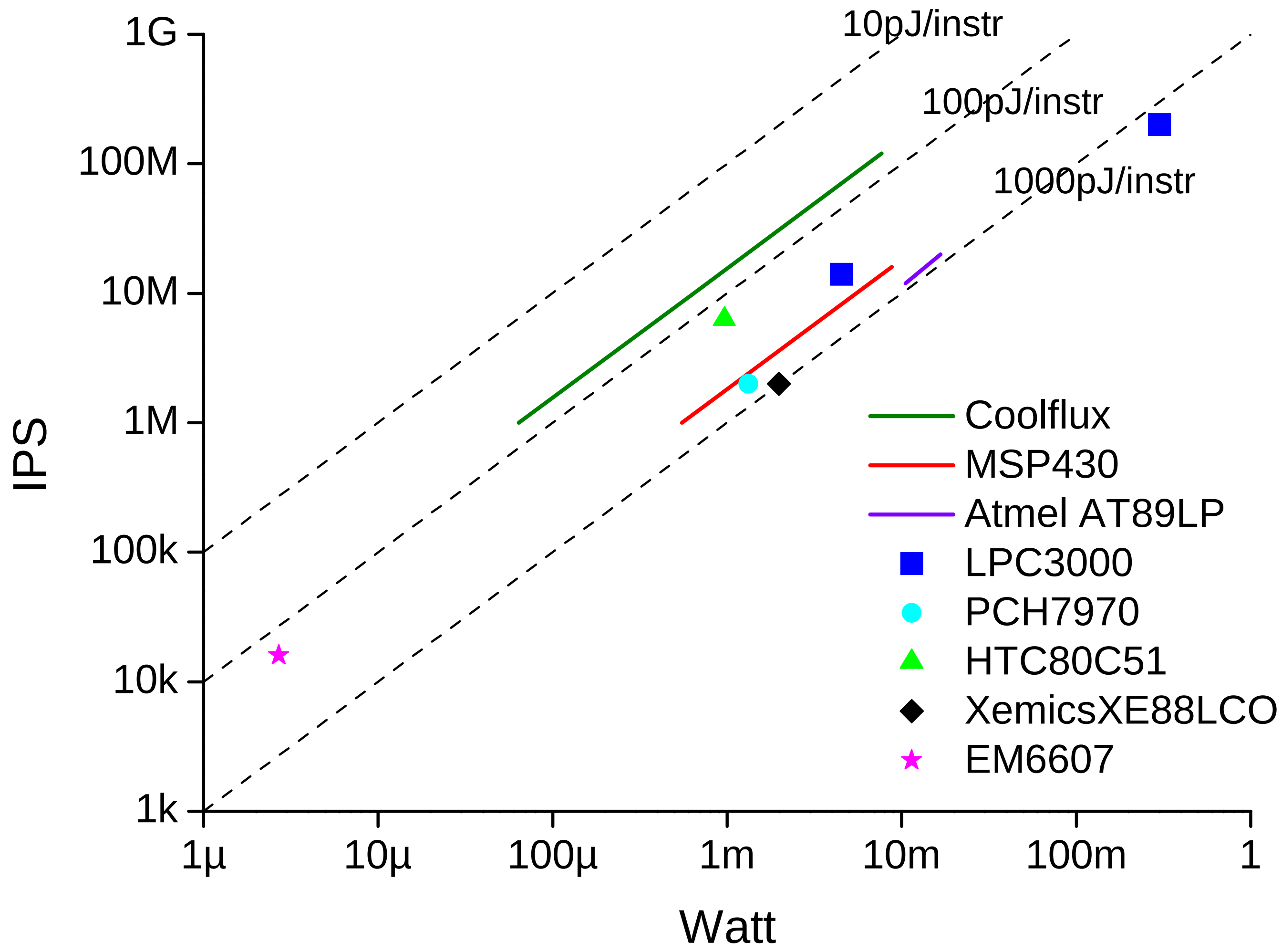
# WSN of flexible nodes



1 CM$^3$



# Microcontroller comparison



# European projects

# WASP

EC IST funding, IP, 19 partners, 10.1 ME funding

3 years. Leader: Philips Research

Purpose: Systems of many autonomous moving objects validated in set of future applications

<u>Philips Research major interest</u>

WP2,3, Moving object infrastructure

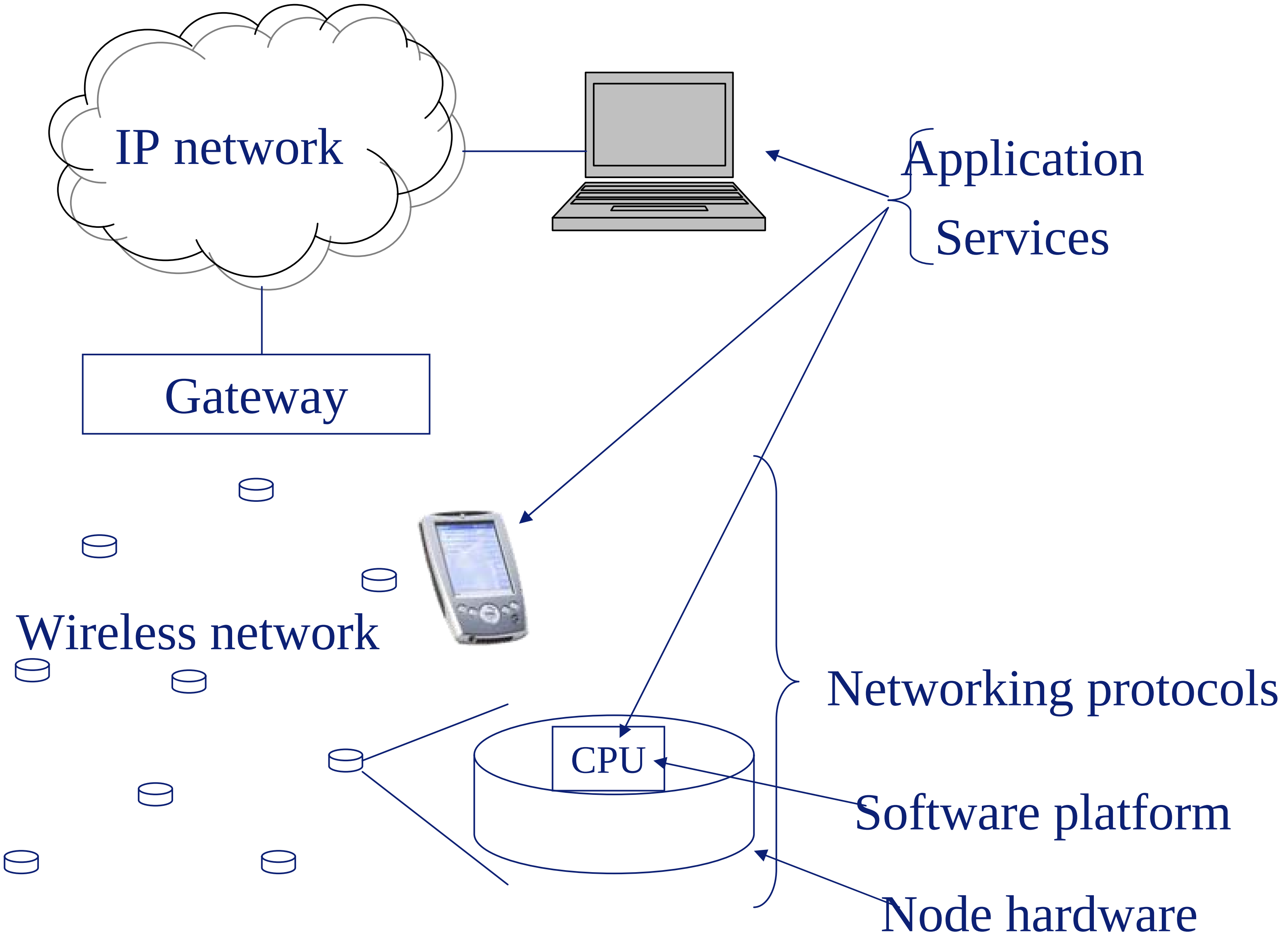
1. Modular 3D sensor nodes
2. SW infrastructure of network of moving objects
3. Validation to applications
4. Security aspects

# Targeted applications

- 50.000 km highways in Europe
- 50 sensors per km.

- UK, France, Italy, around 60 million people
- 20% need elderly care, 2 rooms per couple
- Each room 100 sensors.

- US, 71 million cows,
- 5 sensors per cow.


IP network
Application
Services
Gateway
Wireless network
Networking protocols
CPU
Software platform
Node hardware

# e-CUBES

EC IST funding, IP, 21 partners, 13.7 ME funding

3 years. Leader: Infineon

Purpose: micro system technology for miniaturized, autonomous systems for ambient intelligence

Philips Research major interest

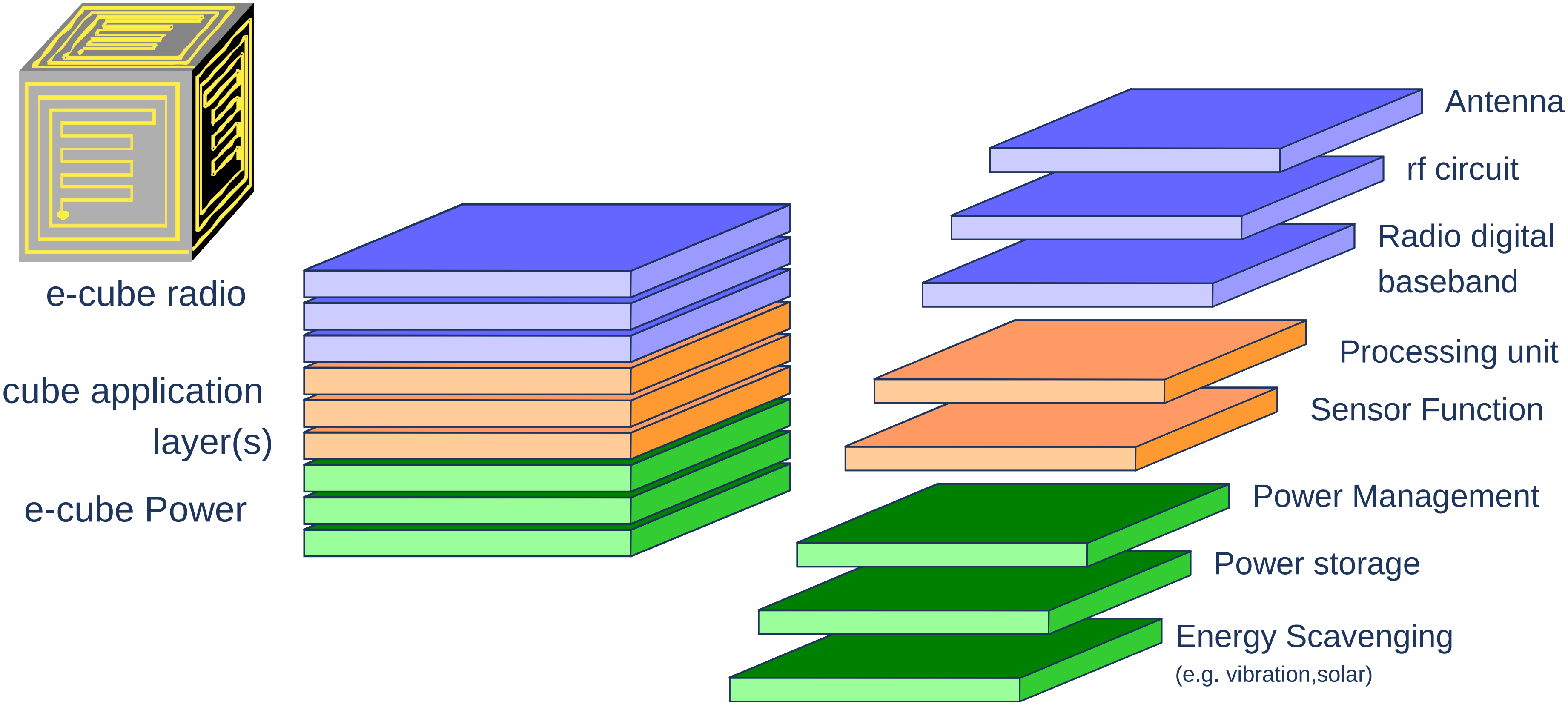
SP3, Integration technologies

1. 3D integration technologies
2. Sensor technology and chips
3. Application scenarios and architecture

# E-CUBES Technologies

- Individual technologies at various layer levels, suitable for 3D integration,
- Layer processing/thinning technologies for 3D integration, 3D assembling and packaging,
- New communication means, e.g. antennas, passive and RF integration, and communication networks,
- Power supply and power management for portable applications,
- Design methodologies for the 3D SoC and related simulation tools. (Particularly the routing and wiring possibilities and the thermal effects are a potentially critical and strategic issue to be addressed in terms of design, optimisation and simulation.)

# e-CUBES Basic structure




Basic structure of an e-CUBES system:
3D stacking of functional sub-system layers

# Personal interests

# Network size

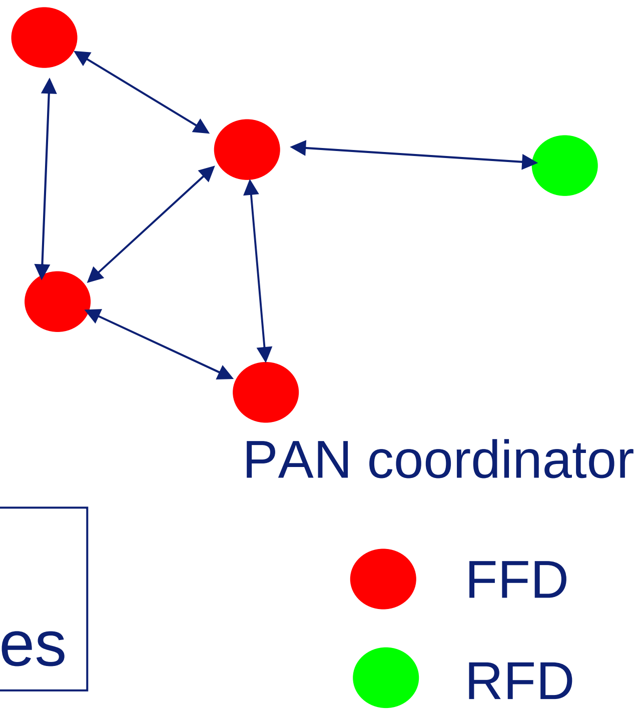
Ambient Intelligence view suggests millions of communicating interconnected nodes (here research is very visible)

Body networks suggest tens of interconnected nodes with a gateway (Dynamic configuration)

Building control suggests a few thousand interconnecting nodes (Static configuration)

# Networking standards

UWB is not there yet




IEEE 802.15.4

packet size 127 bytes

header size 25 bytes

security header 9-21 bytes

| ZigBee | | IPv6 | |
|---|---|---|---|
| header | 15 bytes | header | 48 bytes |

rigid configuration flexible

Listening switched off for power reduction

# Data abstractions

Herd is composed of “connected?” cows

Cow has attributes: temperature, identifier, history

Attributes are delivered from a set of sensors on one cow

Simple question:

“How many cows are ill?”

relies on inter-operability

needs standardization of:

types, abstraction concepts, rules for concepts

Efficiency: which nodes answer and calculate result?

# Programming model

application program does not address individual nodes

“publish/subscribe” or “tuple-space” model

Sensors in a cow may share the cow tuple space

Body sensors publish data, gateway subscribes

gateway stores in tuple space, read by applications

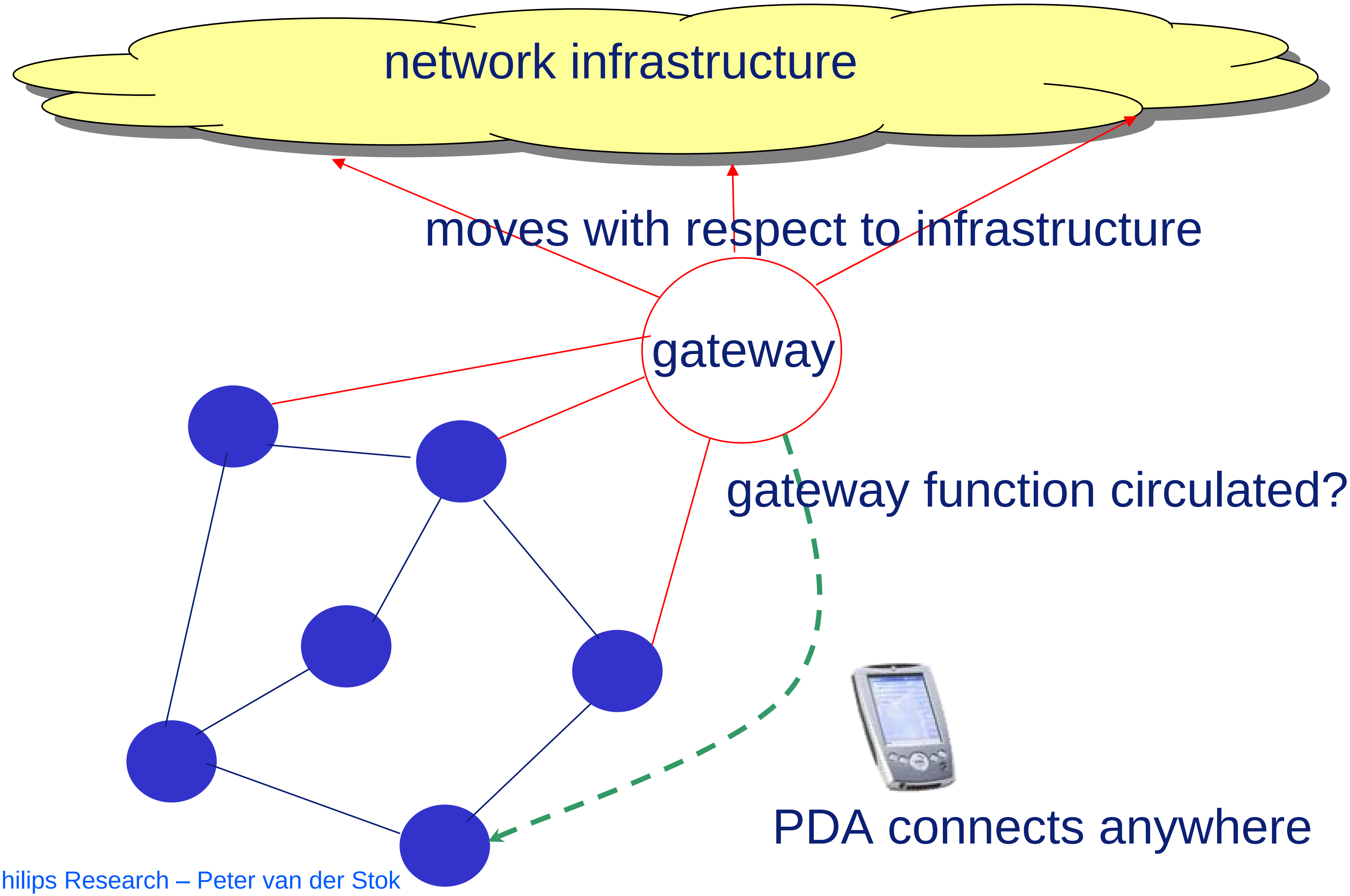
standardization

Efficiency at lower level not seen

by application program

?

# Nomadic WSN


network infrastructure
moves with respect to infrastructure
gateway
gateway function circulated?
PDA connects anywhere

# Gateway functionality

Assumption:

Pair-wise communication between gateway and sensor nodes

Consequences:

-Tuple space in GW

-pub-sub in nodes and GW

-Interpretation of abstractions

-pair-wise security keys

-PDA connects to GW

# Programming model support

| | | |
|---|---|---|
| pub-sub | | presentation |
| | source-destination | |
| topology | | transport |
| | hints | |
| application –driven routing | | network |
| MAC | | link |

*Meeting deadlines, energy conservation, synchrony*

# Programming development

Support for

- Configuration
- Gateway services
- Data and service description
- Programming model (e.g. energy)
- Maintenance services for debug, updates, monitoring

# Conclusions

Applications in health and well-being,
centered around small WSN (5-20) nodes,
nomadic in static building networks.

Software needs to integrate
-programming model
-energy efficiency
-timeliness
-synchrony
-security model

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