Wireless Sensor Networks:

Is it worthwhile after at all ?

FROM RFID TO THE INTERNET OF THINGS

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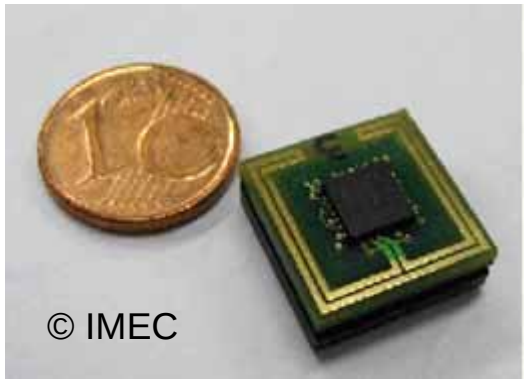
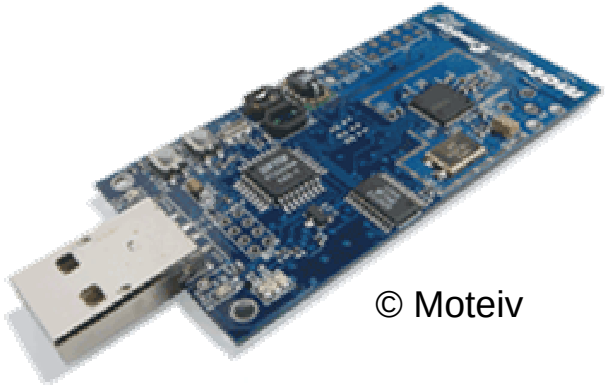
RWTH RHEINISCH-WESTFÄLISCHE TECHNISCHE HOCHSCHULE AACHEN

Life Lesson #113;
(some outragerous comments: this is not a talk)

Friends may come and go, but enemies accumulate.

State of the Art (hardware)





© Smiths detection

A kind of boring…

State of the Art

- Increasing prevalence of networked embedded systems
  - inherently heterogeneous and dynamic
- So why do we not have heterogeneous, dynamic, large-scale systems applications already?
  - Interaction and scale **too complex**
  - Do not have necessary (software) **infrastructure**
- **Hardware:**
  - **Will be handled anyway…**it would be foolish to claim that sensors are driving the micro- and nanoelectronics revolution.
- The *software fabric* of such systems tends to be ad-hoc
  - little provision for generalisable and reusable abstractions and services: applications are bespoke and limited

Need a *generic programming platform*

- need abstractions and services that can span the full range of networked embedded systems
- need consistent mechanisms for *configuring*, *deploying*, and *reconfiguring* systems; **must be small, simple, efficient and highly tailorable**

Life Lesson #126

Leadership:

finding out where everyone is going and running like hell to get out in front.

Quo Vadis?

- **“Where is the vision for Telecom?“**

cf. Robert W. Lucky (May 2004 Spectrum)

- **World is full of wonderful things...like...**
  - ”3G revolution”
  - “**Ad hoc** networks everywhere”
  - “Bluetooth revolution”
  - WAP – Web in your pocket
  - ATM
  - Should we be “user centric” in our planning?


International Business

TELECOMMUNICATIONS

TALE OF A BUBBLE

How the 3G fiasco came close to wrecking Europe

The Mighty Have Fallen

NOKIA

VODAFONE

DEUTSCHE TELEKOM

FRANCE TELECOM

- And there is an annoying tendency to believe that building wireless networks are easy!
  - BUT Proof of Existence tells otherwise…***killers are difficult to predict***

Pervasive Networks – A Long Road Behind

- Vannevar Bush
  - MEMEX (1946)

- Engelbert (1960s)
  - Workstation
  - Ad hoc connectivity

- Mark Waiser (1986)
  - Xerox Parc

- Vint Cerf (1992)

Major Role Schism

Cool research on general domain

Yet-another-Application on…

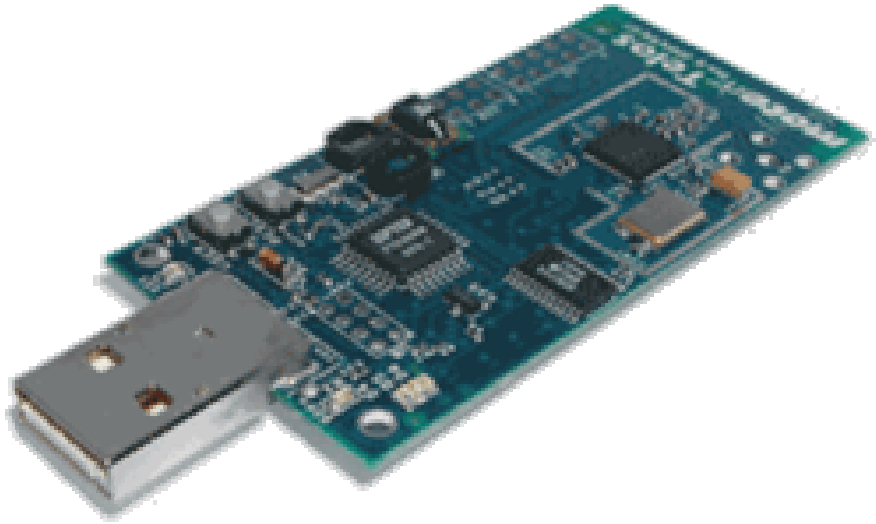
-Security
-Biohabitat
-etc.

Research searching its taker?
So where is the beef?

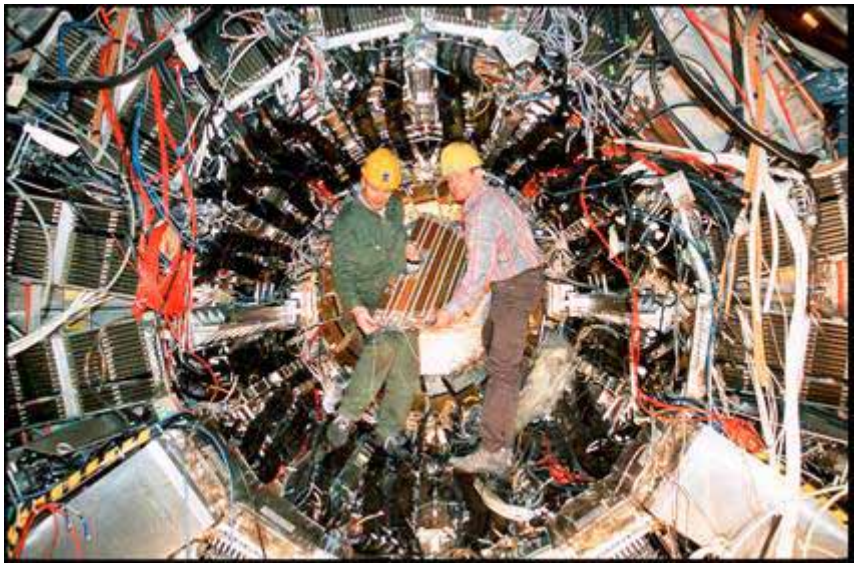
Massive ad hoc and sensor networks

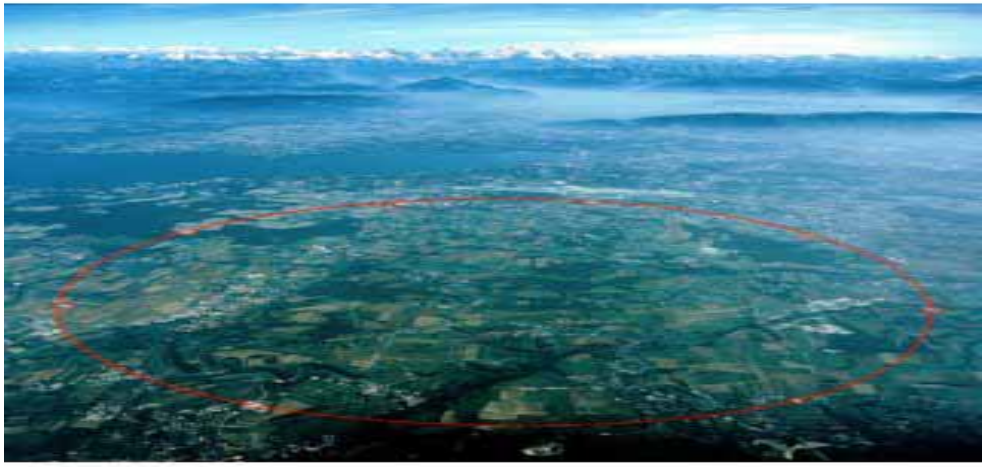
- Wireless Sensor Network may not be a special class of ad hoc networks, but people are trying their best to make them such.
- Some “easy” application domains
  - Military, civilian emergency response,…
- Harder to see what are massive applications for ordinary “consumer markets”
  - Should we *even* care?
- Sensors have a good long-term potential, but one has to remember that they are already USD 1B market
  - As such there exists knowledge
  - Sensors Markets vs. Wireless Sensors

You call that a sensor…?

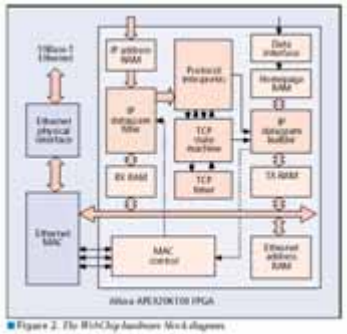


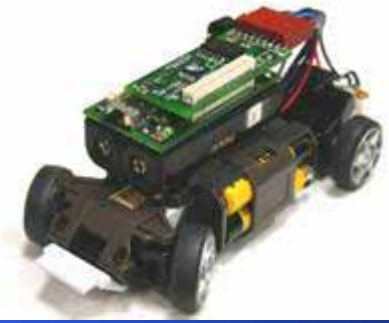
This is a sensor…

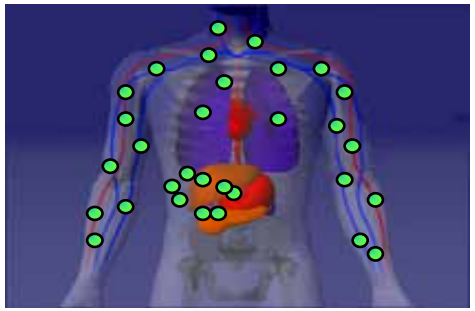




smeagol







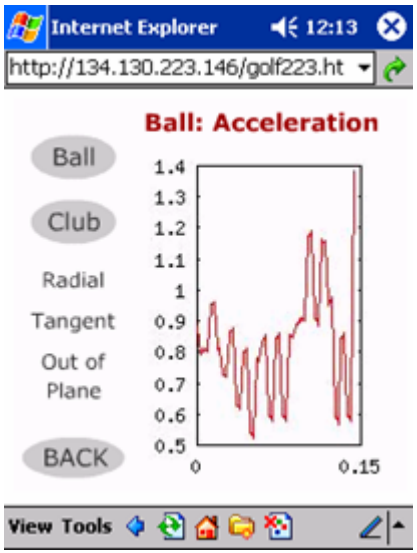
Valuable bits

Locate(HomeDoor,StreetAddr)
Identify_Authenticate()
Give_Status(Lock)

Response(HD,Lock)

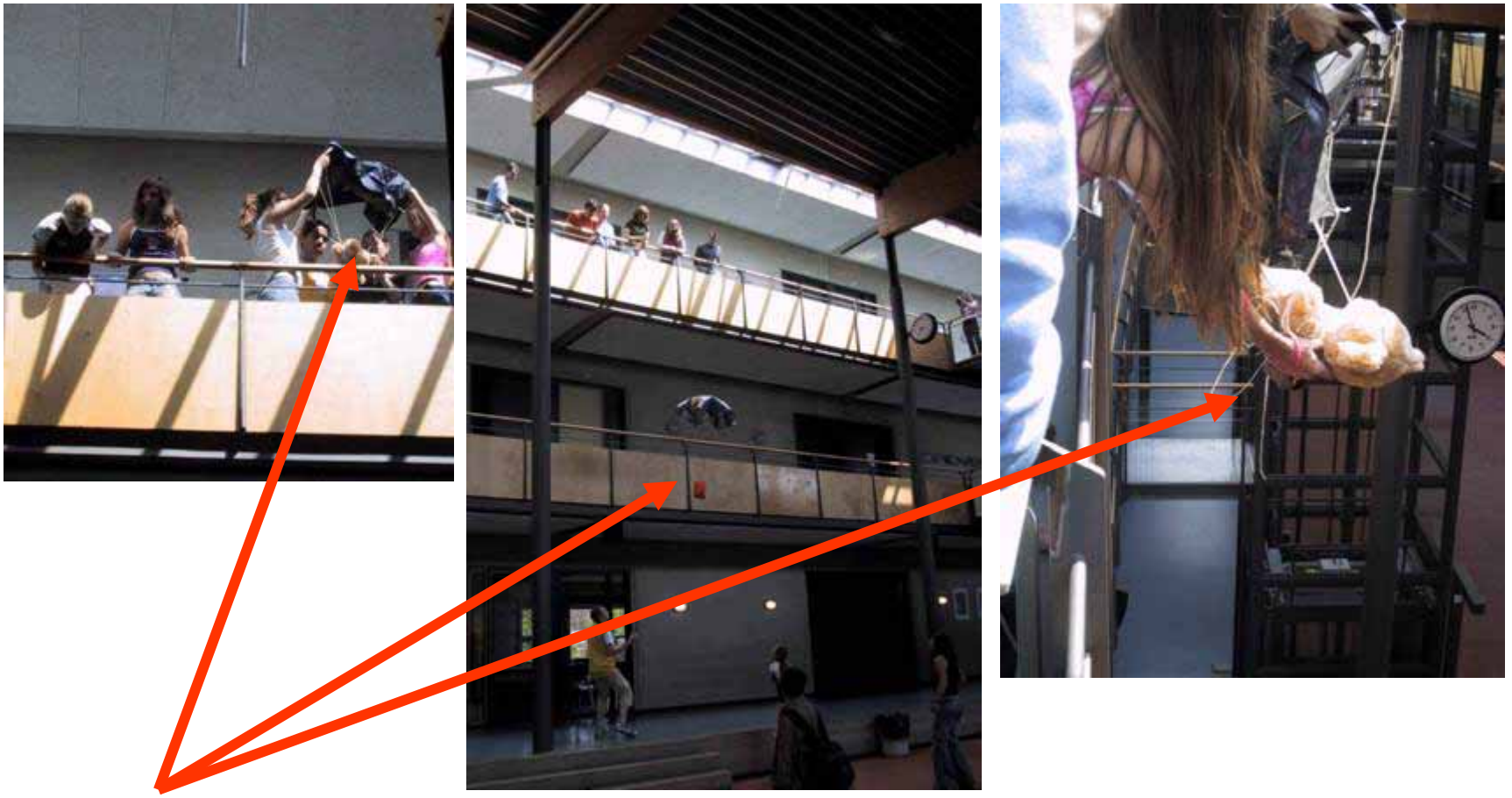
Door_is_Locked

Sports



Rehabilitation, Medical

Parabears á la Maastricht



“Payload”

Some recognized domains

- **(Heavy) Process Industry**
  - Wonderful, but their QoS requirements set is killing us currently
- **Logistics**
- **Cars**
  - But none of the safety critical systems…
  - …but opportunities on some user comfort
- **Meteorology**
  - Interesting, but not really much cost-optimization problems
- **Mobile Phones**
  - As an ubiquitous sensor platform…
  - …for something.
- **Mining and Oil industry**
  - Safety critical monitoring
  - Massive scale data gathering
    - “We need 15-40 AtmPress. survivability”
    - Life-time for sensors; 4-8 years
    - Camels are eating those, we want them back

Somewhere in the world…

1999

RUNES

Thanks Steve and RUNES

Mont Blanc

- **Wednesday morning, March 24, 1999, 10.46 AM**
  - The Belgian Gilbert Degraves, 57, a truck driver for 25 years drives his Volvo FH12 tractor trailer and a refrigerated trailer loaded with 9 tons of margarine and 12 tons of flour for Italy past the toll at the French side.
  - Nothing abnormal was visible.
  - Ignition must have started about now..

Mont Blanc

- **10.54, 8 minutes a.i.**
  - A phone call from area 22 is received at the Italian control room.
  - Smoke is detected on the video monitors between areas 16 and 21.
  - **On the Italian side, trucks stop, drivers leave their cabs see a thick wall of black smoke under the ceiling. They all managed to escape on foot** - the airflow blew smoke away from them.
  - **On the French side and 2 truck drivers** up front left their vehicles and run back towards the French entrance.
  - They **died probably of toxic smoke 200 - 240m away**.
  - Car drivers also tried to escape but they managed to make only 100 – 500m before dying. Most other drivers stayed in or near their vehicles.
  - **27 were found dead in the wrecks.**
  - **Lack of oxygen brings engines to a halt.**

Mont Blanc

- **11.02, 16 minutes a.i.**
  - The Courmayeur firefighters are alerted. At the same moment the first fire engine leaves its base at Chamonix.
  - The Italian fire detection **system loses all transmission data** from the acquisition cabinet in area #19.

- **11.10, 24 minutes a.i.**
  - The first firefighters from Chamonix arrive at the tunnel and immediately drive inside. Meanwhile short circuits cut more and more of the lighting system.

Mont Blanc

- **`11.24, 38 minutes a.i.`**
  - The commander of the Chamonix' firefighters arrives and is informed of the situation.
  - **Everything is very chaotic, nobody knows if and how many people are still inside. Survey cameras show nothing as black smoke** if they work at all. No coordination is made with the Italian side's operators.

Somewhere in the world…

2019

What if…

- Sensors, embedded systems are pervasive
  - Tunnel
  - Cars
  - People
- They are networked
- Firefighters can
  - Query status of the network in advance
  - Visualise the information
  - Change the environment – actuators
  - Communicate with victims

But in that case stop messing around with your toy projects!

What if: 1:100 of these had a radio tag with DNA chip

Problems:

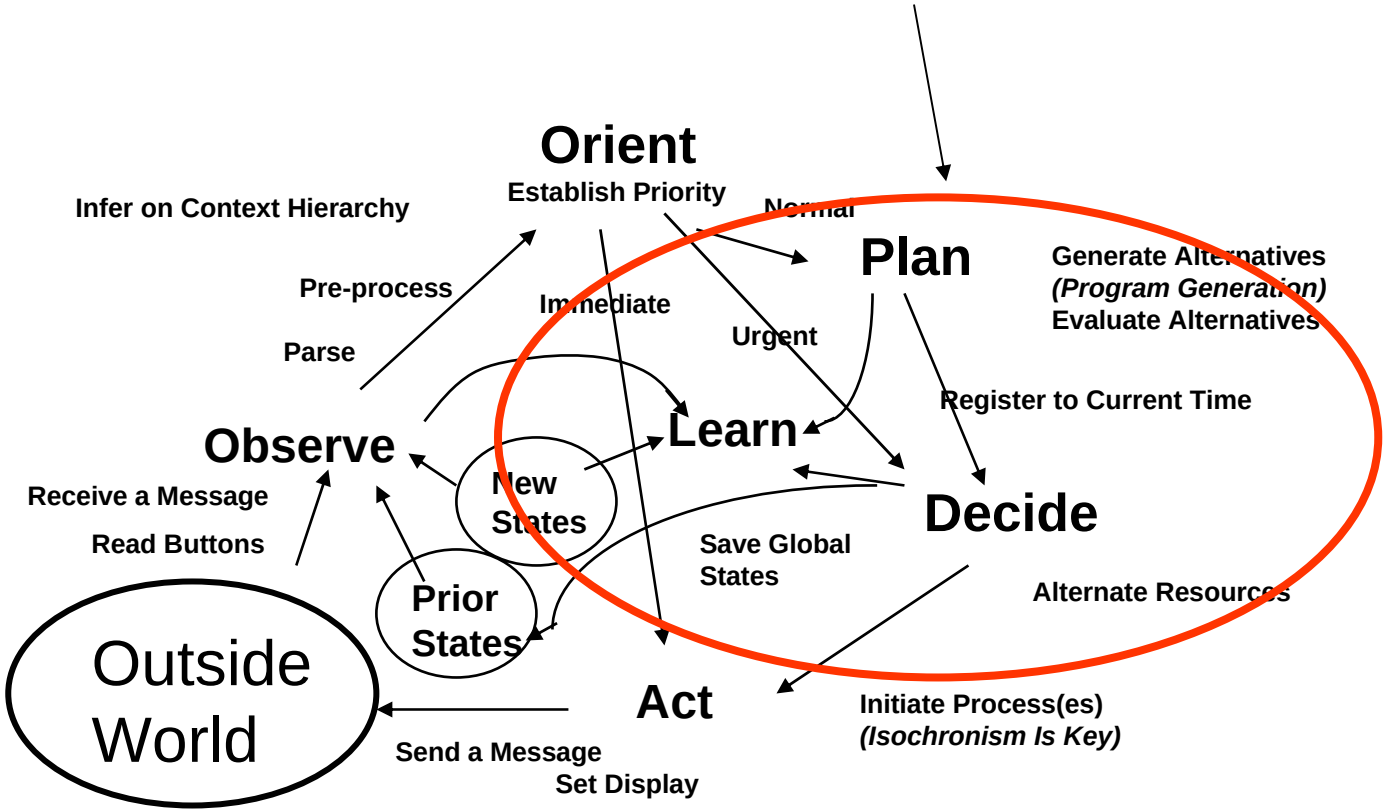
- There is no “universal” models for sensor and embedded networking
- Better Programming and deployment paradigms are still urgently required
- Currently almost all work is mostly “nice emonstrations” (impressive ones though)
  - And yes hardware could be made better
- Sensor Capability [resource] and Service Discovery ?
- Capacity…did I say capacity…this is a killer
  - Generally speaking multi-hop and dense low bit-rate networks are something to give you a headache!

SQL of the Real Physical World

- How to query the real world?
  - TinyDB and its friends…
- But we need more…use of AI paradigms
- How to extend the queries?
  - Take me to your leader?
  - Which leader do you mean? …
- How to learn and build rules from Physical World Description?

Cognitive Wireless Networks with smart optimization methods

Make it Smart?



The Cognition Cycle

Mitola, “Cognitive Radio for Flexible Mobile Multimedia Communications”, IEEE Mobile Multimedia Conference, 1999, pp3-10 – and Mitola, Ph.D. Thesis, KTH (2000)

BRINGING CIVILIZATION TO ITS KNEES...

And last but not least…

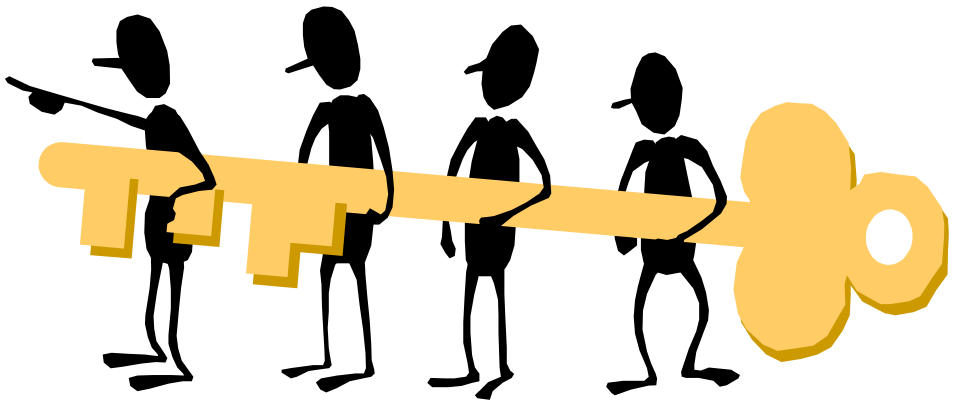
- Call in sociologists, lawyers, economist, and couple of philosopher (moral and ethical experts)
  - Pervasive networking, if scaled to its ultimate and logical end-point starts to mess up with privacy and our social structure.
  - We should not drive into the tunnel without our lights on!
  - See e.g. EU funded SWAMI (Safeguards in a World of Ambient Intelligence)

FP7:

- Embedded Networking including sensor is definitely worthwhile research domain, if ***interdisciplinary*** covered and conducted with a reasonable program.
  - Stop messing around with non-coordinated approach
- Make a distinction with “Me Too” and “Real” research
- Support academic long-term, high-risk smaller projects
  - including AI, capacity estimation bounds, topology issues
- Support realistic industrial projects
  - With large and semi-real deployment, not “me too” deployments
- Understand difference between the above
- Reward the expertise and *relevant* track-record

Q&A

in coffee break



The RUNES programming model

- A generic **component-based** programming model
  - Components allow for a unified way of accessing, configuring and reconfiguring the system
  - Encapsulation behind well-defined interfaces
  - Basis of dynamic adaptation & reconfiguration
  - Inspectable, adaptable and extensible at runtime
  - ‘low level’ and efficient; can employ different implementations on different hardware
- Applied uniformly throughout the stack
  - network, OS, middleware, applications
  - *all above uniformly realised as reconfigurable compositions of components*
- **nanoIP (RWTH) and microIP (SICS)**
  - Running TCP over sensors is not a good idea at all
  - **nanoSLP** and **nanoHTTP**

Component frameworks (CFs)

- **Re-usable**, **dynamically-deployable**, **software architectures**
  - give structure, tailorability and constraint
  - built as compositions of components and/or other CFs
- **Provide "life support environments" for plug-in components in a particular area of concern**
  - example: a protocol stacking CF that takes plug-in protocols
  - the caplet/ reflective extensions are themselves CFs
  - other examples follow…
- **Embody constraints on pluggability**
  - example: disallow stacking of IP plug-in above TCP plug-in
  - constraint specification may be ad-hoc
  - or may employ generic constraint languages such as OCL (with automatically generated run-time machinery)