

7th FRUCT conference Saint-Petersburg 26-30 April 2010

Experiences on the Development and Pilot Testing of Autonomous Wireless Sensor Networks

Marko Hännikäinen
Tampere University of Technology



Outline

- History and introduction to WSNs
- TUTWSN technology
- TUTWSN pilots
- Conclusions



Wireless Sensor Networks

- WSN consists of a large number of nodes that organise autonomously
- WSN nodes are resource constrained (limited computing, communication, and energy)
- WSN targets at low price, small size, robustness, maintenance freedom and fast installation
- WSN applications are versatile, they
 - Measure environment
 - Control other systems
 - Identify, locate persons and assets
 - Transfer, save, and refine information



Main WSN standards



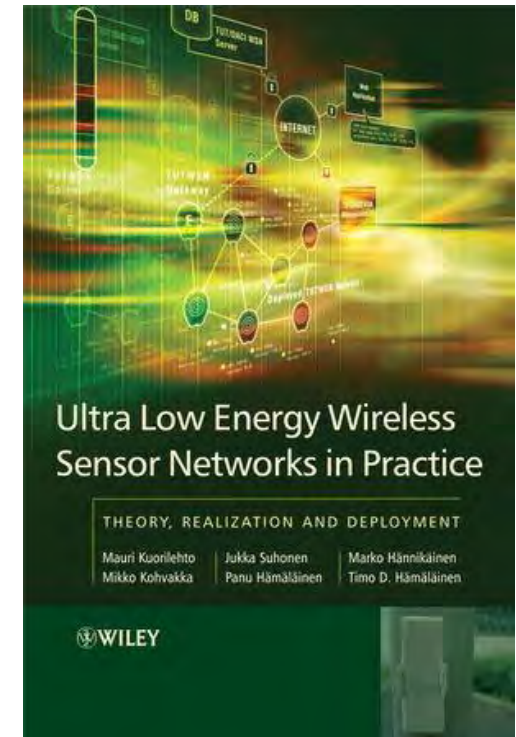


WSN research at TUT



WSN Research on Low-Energy WSNs in Practice

1. WSN theory and technology
2. Design tools and infrastructure integration
3. Applications and services
 - Pilots in real environments and application cases
 - Feasibility on business models



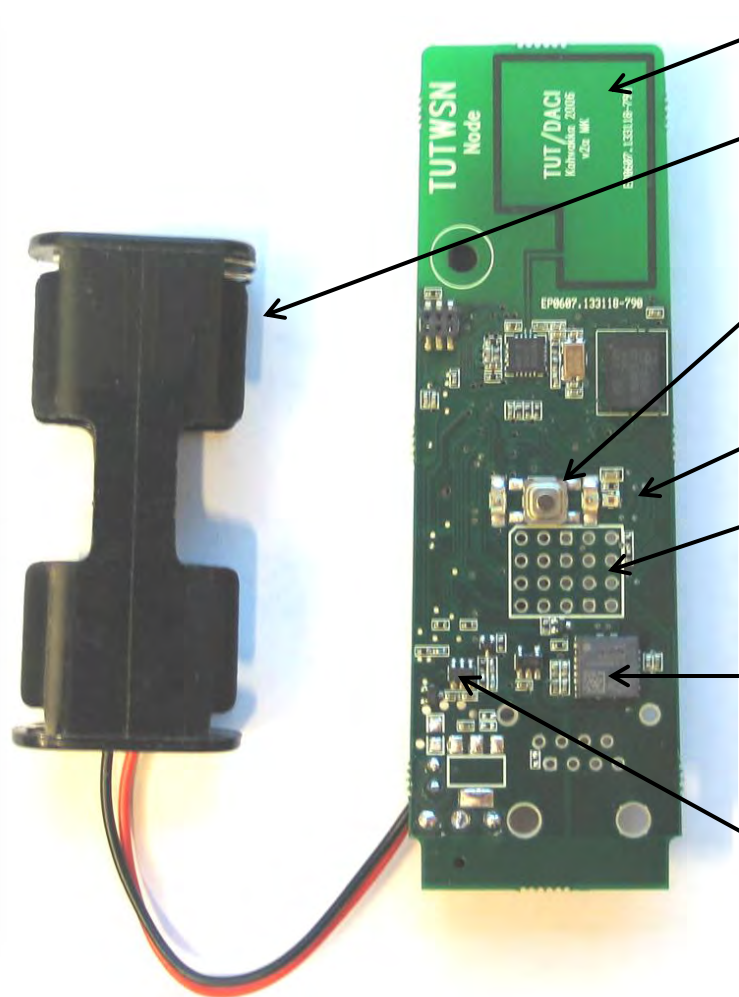
Technology base
1999-2005

First pilots started
2006

Pilots with
companies 2009-

2002 2003 2004 2005 2006 2007 2008 2009 2010

TUTWSN (2.4 GHz), wireless sensor/router node



Loop antenna

Battery holder

Pushbutton
2xLed

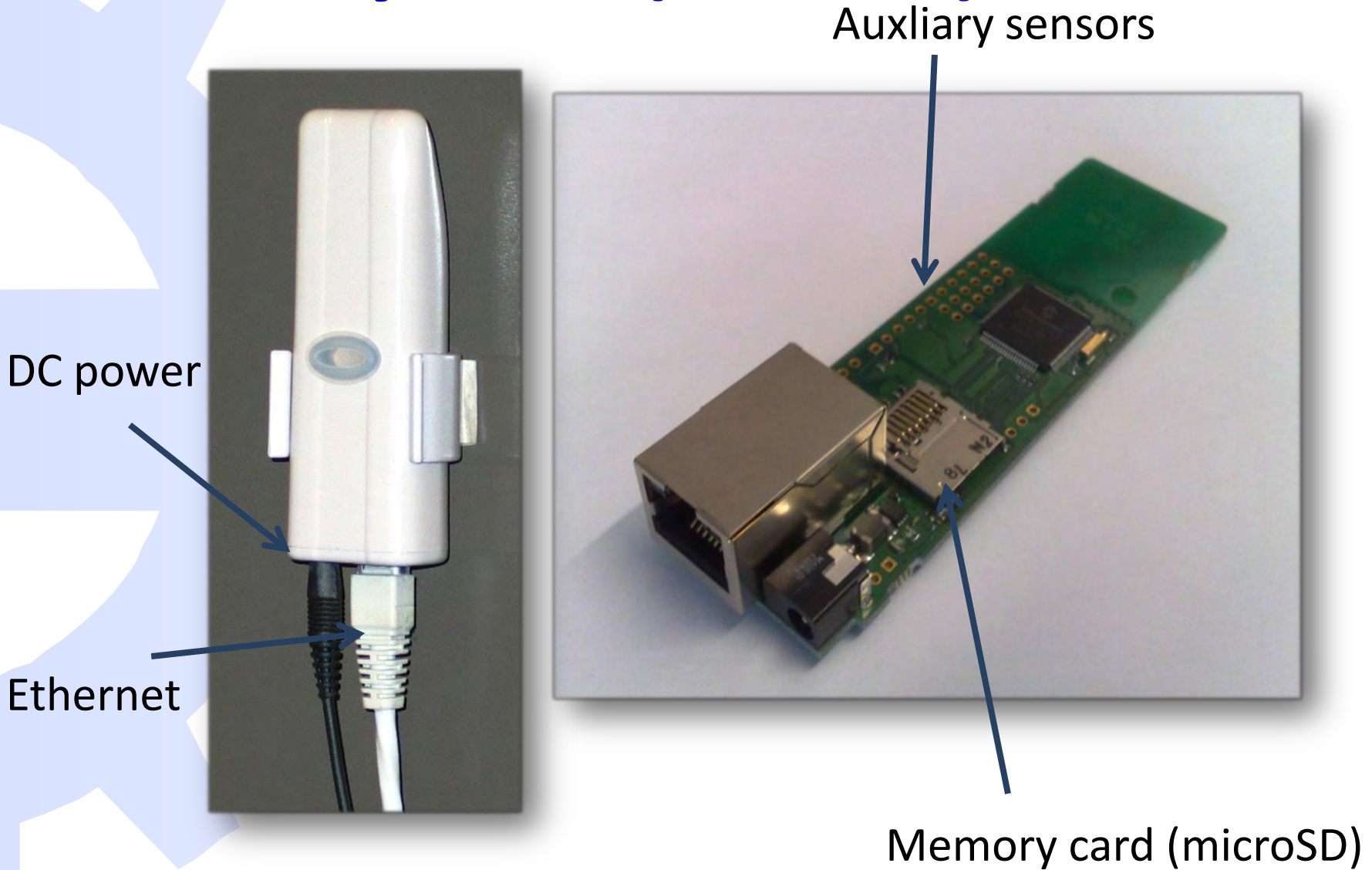
Lux sensor

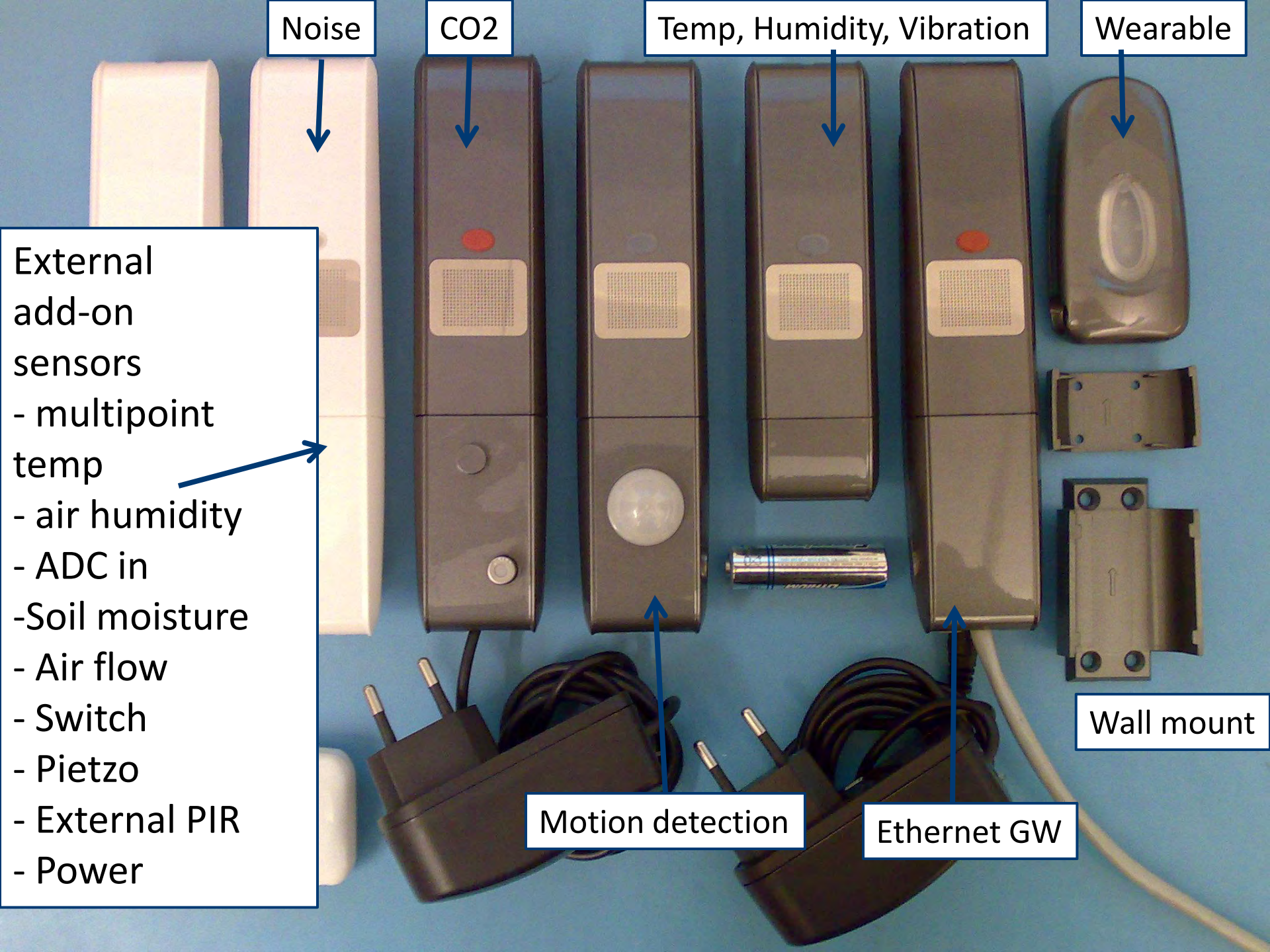
Extension area for
add-on sensors

3D vibration sensor
(shock detection)

On-board temp
sensor

Gateway node (2.4 GHz)





Noise

CO2

Temp, Humidity, Vibration

Wearable

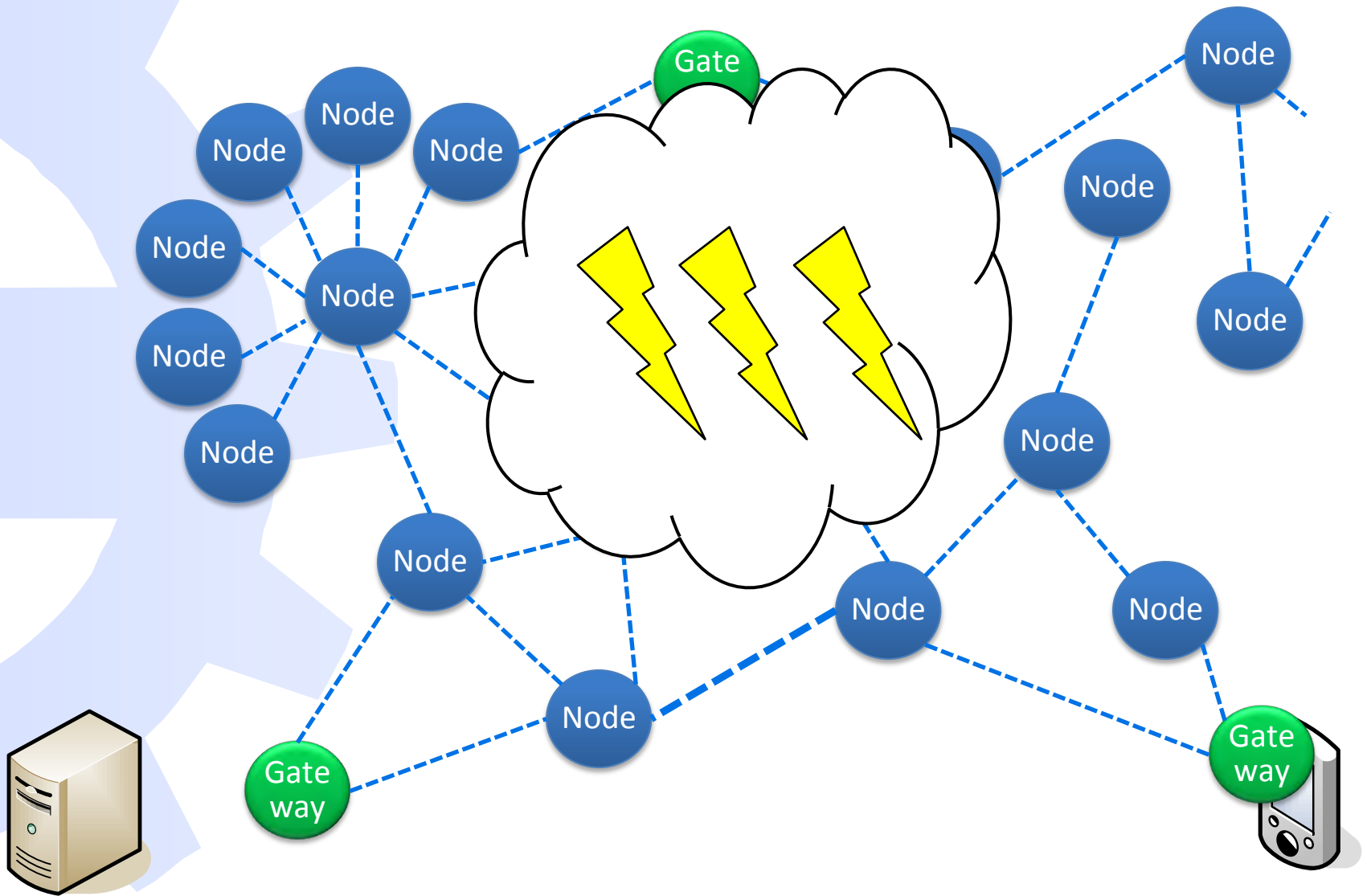
- External add-on sensors
- multipoint temp
 - air humidity
 - ADC in
 - Soil moisture
 - Air flow
 - Switch
 - Pietzo
 - External PIR
 - Power

Motion detection

Ethernet GW

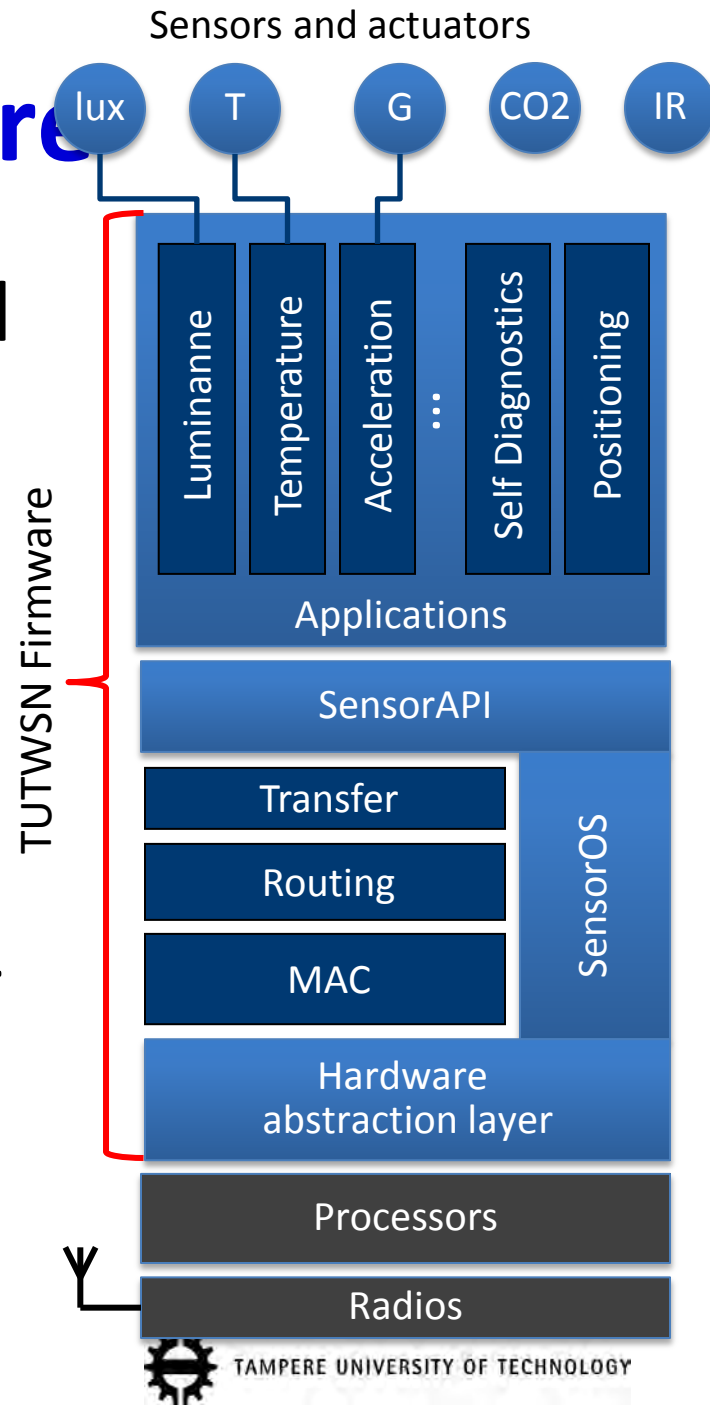
Wall mount

TUTWSN networking



TUTWSN node software

- Node is an embedded system running protocols and several applications
- Interfaces for RS232, I/O, Ethernet (TCP/IP), sensors
- Energy optimised MAC layer and cost-based multi-hop routing
- Firmware can be updated on-the-field
- Performance is trade-off (cross layer design)

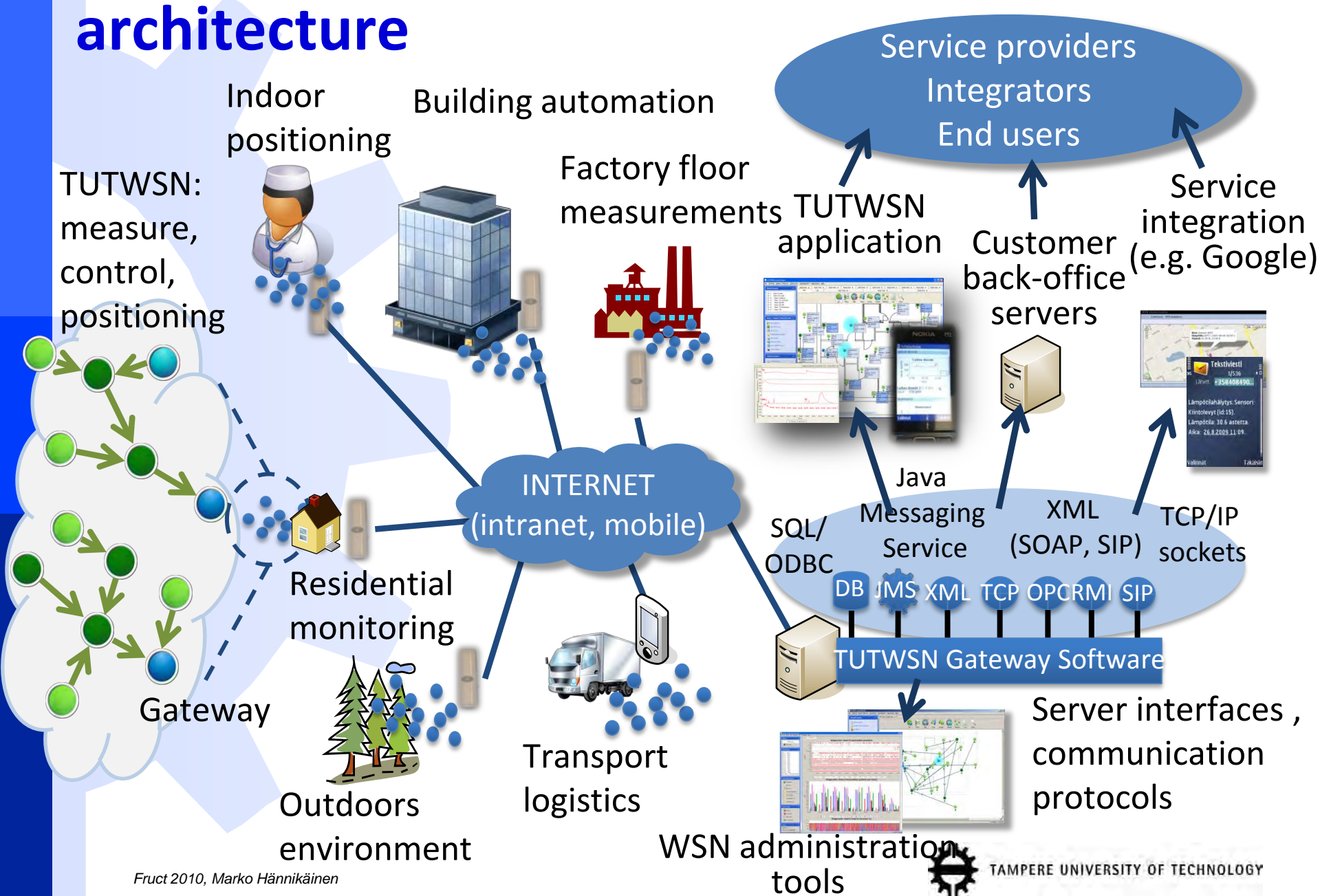




Pilots examples



End-to-end service architecture



Online java, web applications

The screenshot displays the TUTWSN Control Panel interface, which is a web-based application for monitoring a network of sensors. The main window shows a network map with various sensor nodes connected to a central gateway. Each node is represented by a green circle and a data box containing its ID, name, and sensor readings.

Selected nodes list:

- ID: 2 - Name: Pakastin
- ID: 3 - Name: Varasto
- ID: 8 - Name: Työhuone ilmanvaihto
- ID: 15 - Name: Kiintolevyt
- ID: 18 - Name: CO2 työhuone
- ID: 22 - Name: Sisä PIR
- ID: 23 - Name: Kynnys piezto
- ID: 25 - Name: Ulko PIR
- ID: 29 - Name: KHH

Network actions:

- Set node floor
- Set node name
- Show chart
- Motion detection history
- Show status
- Show tech data
- Show neighbor chart
- Unlock position

Network map nodes (examples):

- Mopo (kiihtyvyyys) ID: 12, Sensor1: 15.5°C, 837,79 mg, 0 lux
- Kynnys piezto ID: 23, Sensor1: 16,3°C, 413 lux
- Kukkapurkki ID: 5, Sensor1: 17,0°C, 719 lux
- Ulko PIR ID: 25, Sensor1: 18,0°C, 709 lux
- Varasto ID: 24, Sensor1: 14,0°C, 0 lux
- Makkari ID: 17, Sensor1: 24,0°C, 1 lux, 442 ppm (CO2)
- Paikannettava #2 ID: 27, Sensor1: 23,6°C, 0 lux
- Paikannettava ID: 1, Sensor1: 23,3°C, 1 lux
- Paikannettava #2 ID: 27, Sensor1: 23,6°C, 0 lux
- Sauna ID: 7, Sensor1: 22,3°C, 45,25 RH %, 0 lux
- Paikastin ID: 2, Sensor1: -16,0°C, 0 lux
- Mikrofoni ID: 19, Sensor1: 34,5°C, 3 lux
- Jääkaappi ID: 13, Sensor1: 10,0°C, Sensor2: 9,3°C, Sensor3: 8,1°C, Sensor4: 7,8°C, 0 lux
- LED-node 2 ID: 28, Sensor1: 23,7°C, 4 lux
- Takka ID: 21, Sensor1: 23,3°C, 0 lux
- CO2 työhuone ID: 18, Sensor1: 24,6°C, 0 lux, 435 ppm (CO2)
- Betonipolku #2 ID: 30, Sensor1: 16,5°C, 711 lux
- KHH ID: 29, Sensor1: 24,0°C, 0 lux
- RH (Shower) ID: 9, Sensor1: 24,7°C, 39,08 RH %, 0 lux
- Kiitatio ID: 14, Sensor1: 23,7°C, 2 lux
- Työhuone ilmanvaihto ID: 8, Sensor1: 22,5°C, 38,75 RH %, 0 lux
- Sisä PIR ID: 22, Sensor1: 23,7°C, 0 lux
- LED-node ID: 4, Sensor1: 22,7°C, 13 lux

Mobile Phone (Nokia E51) Notification:

Tekstiviesti
1/536
Lähet: +358408490...

Lämpötilahälytys. Sensori:
Kiintolevyt (id:15).
Lämpötila: 30.6 astetta.
Aika: 26.8.2009 11:09.

Valinnat Takaisin

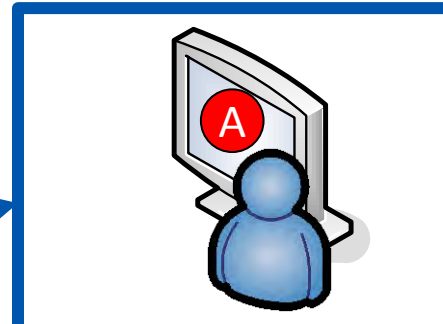
Chart (Selected timeframe: 13.09.2009 17:40 - 14.09.2009 17:40):

- Humidity RH %
- Temperature °C
- Illuminance lux
- Multisensor temperature °C

Got packet from 25: DIAGNOSTICS_NEIGHBOR_INFO

Personnel locationing and alarm button at hospital

Wireless routers and gateways



Monitoring room

Colleague acknowledges alarm

Alarm:
push
button



Sewer line monitoring, a Solvay Chemicals, Voikkaa

- Water level alarms on 5km sewer line
- 23 nodes, 2 Gateways
- 433MHz technology



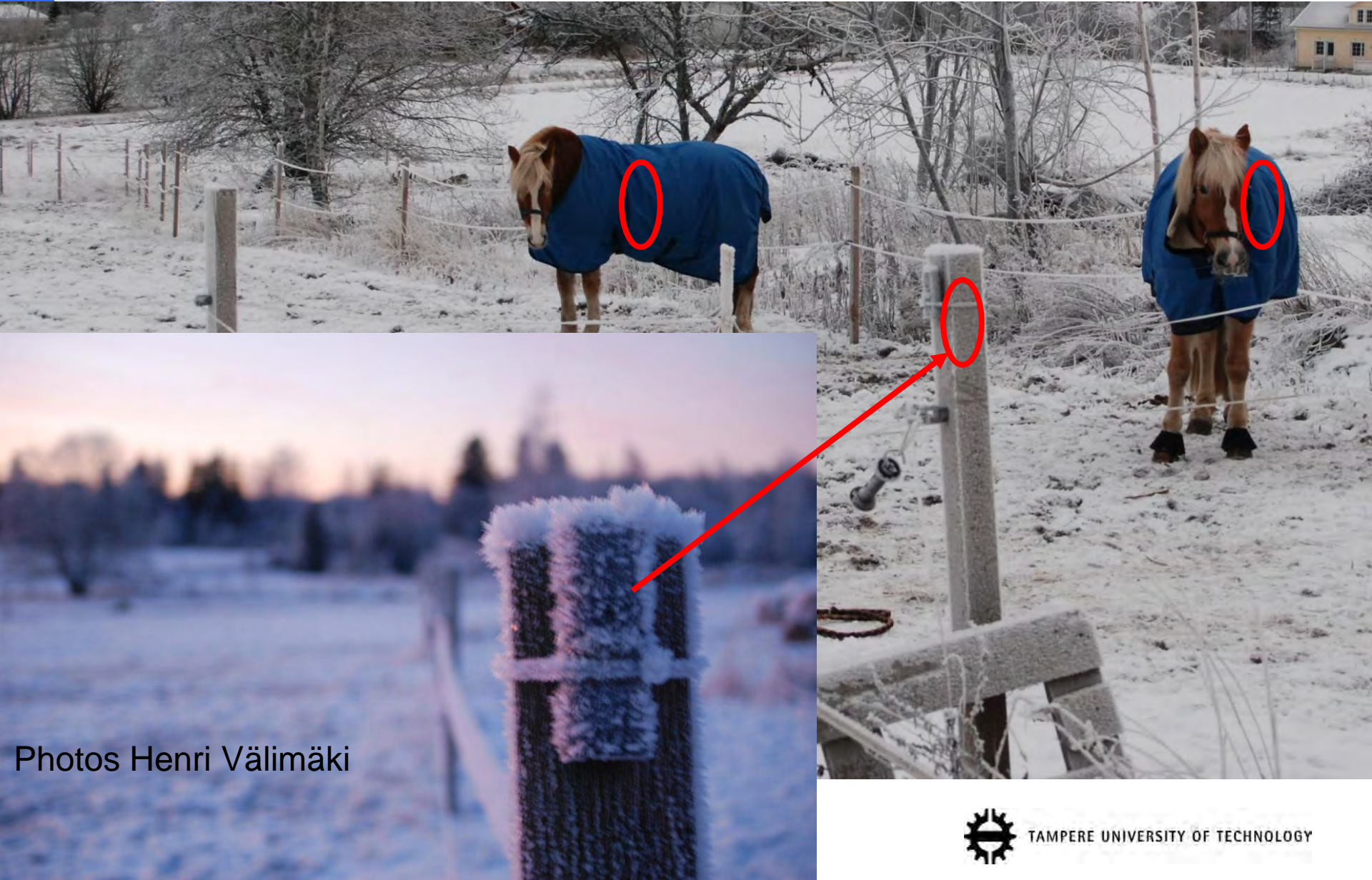
TUTWSN
node

2. pintakytkin

1. pintakytkin

Jätevesiputken
lämpötila

Horse monitoring application



Photos Henri Välimäki

Container monitoring, on a container ship below deck



Outdoors pilot

- 6 km²
- Mainly fields, gardens, lakes, forests, hills
- Up to 70 sensors scattered
- Temperatures, light, moisture



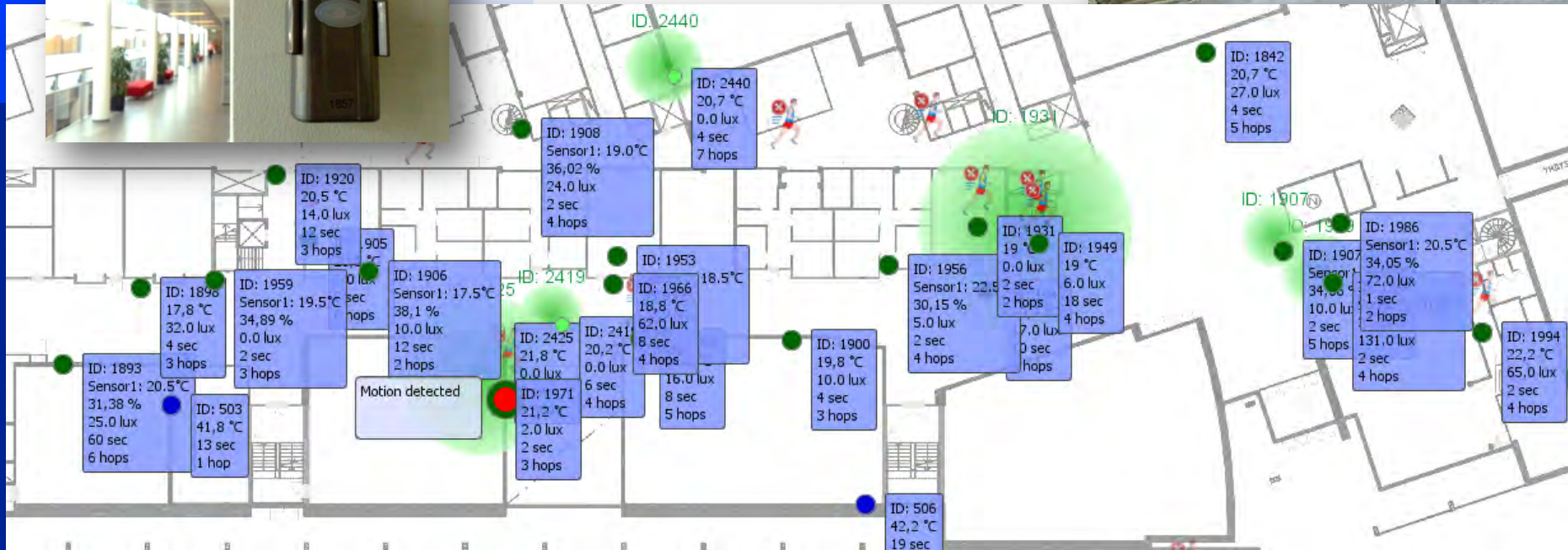
Greenhouse monitoring



- For adjusting greenhouse climate based on WSN measurements

TUTWSN in TUT's campus (about 300 nodes)

- Building automation and maintenance services
- Students design new applications



wsn@home concept

Resident's applications:

- web/java
- mobile browser (+ sms)
- Facebook

wsn@home online services

- Everything ok at home?
- Anyone home right now?
- Someone at the door?
- Freezer is going to break down?
- Is my motorcycle still parked at front?
- Too much CO2 at bedroom?
- TV is on for nothing?
- Garden is too dry?
- Air is too humid?
- Everything ok at the neighbors'?

wsn@home



Conclusions



Conclusions on TUTWSN Pilots and R&D requirements

- Piece-wise solutions, lack of common interfaces and tools -> Cross-layer design
- Lack of killer application & strong belief in killer application -> Niche markets the first to start
- Lack of de-facto standard & strong belief in near future de-facto standard -> WSNs implemented with standard components
- Nice ideas -> New services and business models