Are We Ready to Go Large-Scale?

Challenges in the Deployment and Maintenance of Heterogeneous Networks of Cooperating Objects

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Rome, PECCS / SENSORNETS 2012 Conference

February 24th, 2012

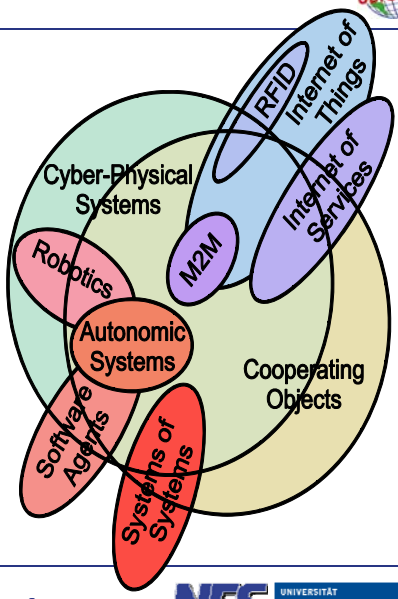
European Center for Ubiquitous Computing and Smart Cities

NO!

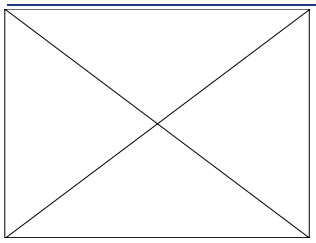
Thank you for your attention!

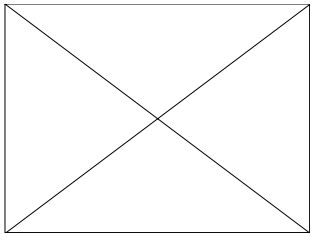
Preliminaries: Terminology

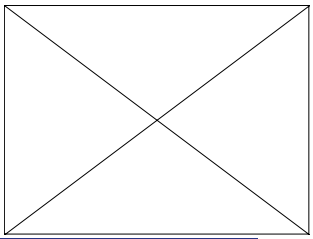
- Cooperating Objects
  - Smart embedded systems
- Internet of Things
  - RFID systems
- Cyber-Physical Systems



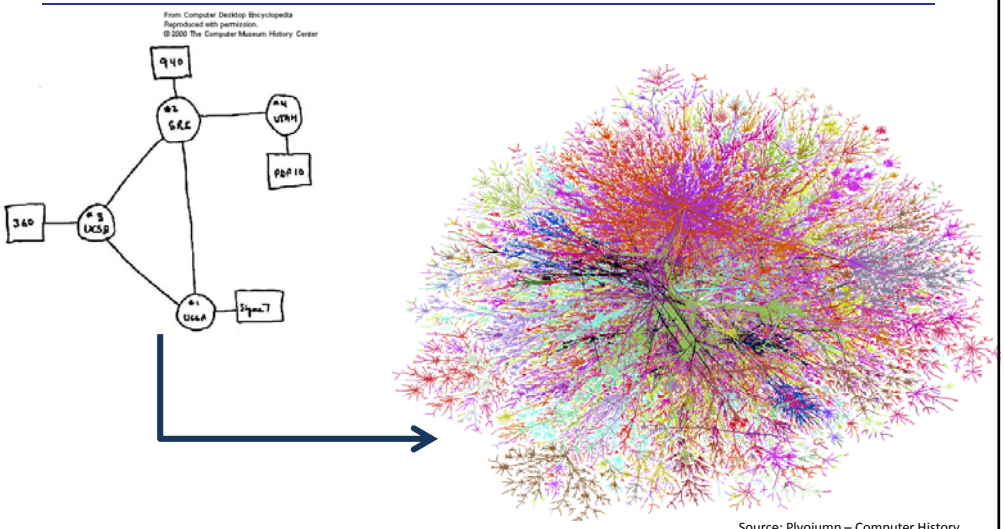
Vision of the Internet of Things





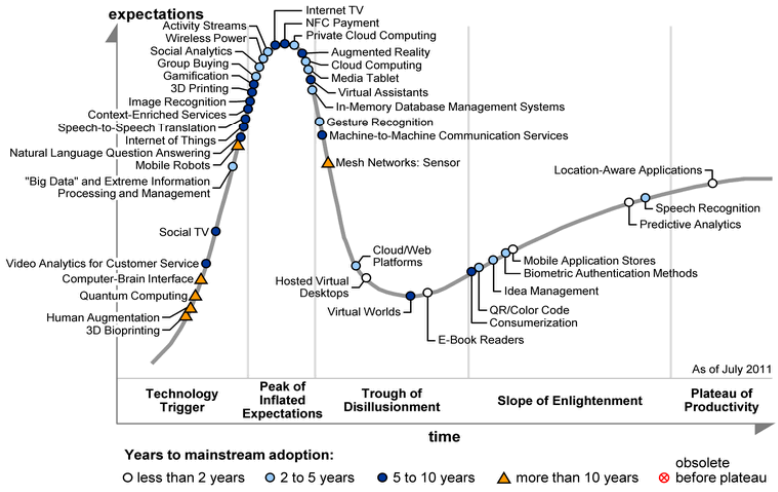


Comparison to “normal” Internet



Source: Plyojump – Computer History

Current Status of the Hype



Source: Gartner 2011

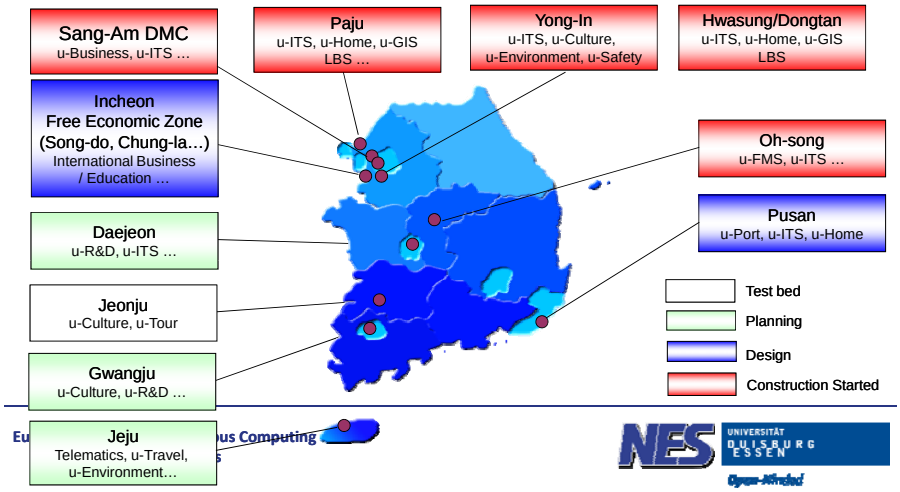
u-Cities in Korea

- New Songdo City to be finished in 2014
- $25 billion approved budget
- Based on smart-cards, RFID technologies, etc.

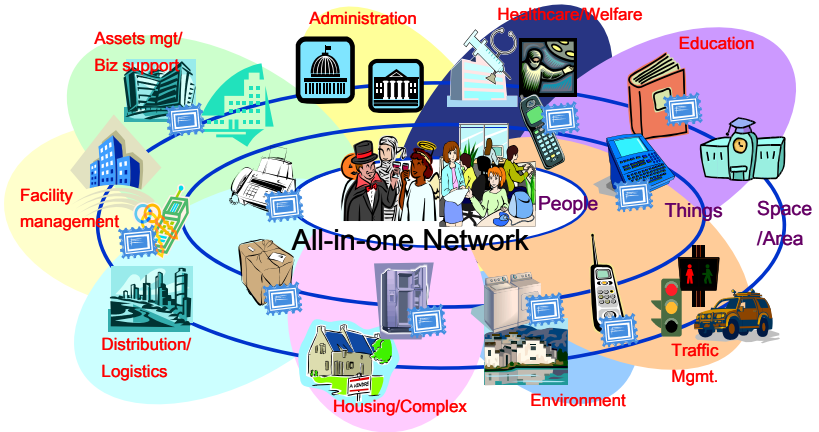
New Songdo City

Status of u-City Trials in Korea

- u-City trial projects activated in 22 cities
  - 14 existing cities and 8 cities under construction
- Interoperability and over-construction problem
  - Local province driven construction of u-City without common service model/standards



u-City: Conceptual Framework



BcN, FTTH, GPS, UWB, Bluetooth, Zigbee, SoC, RFID, MEMS, Embedded SW, IPv6, Cryptograph /Security

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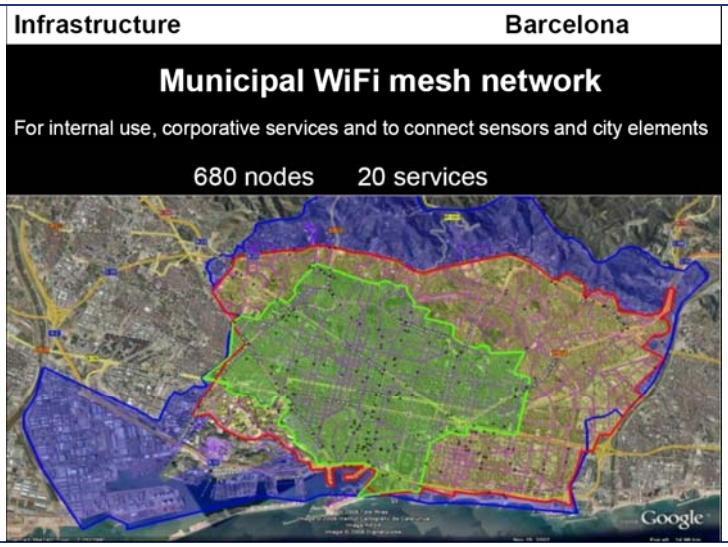
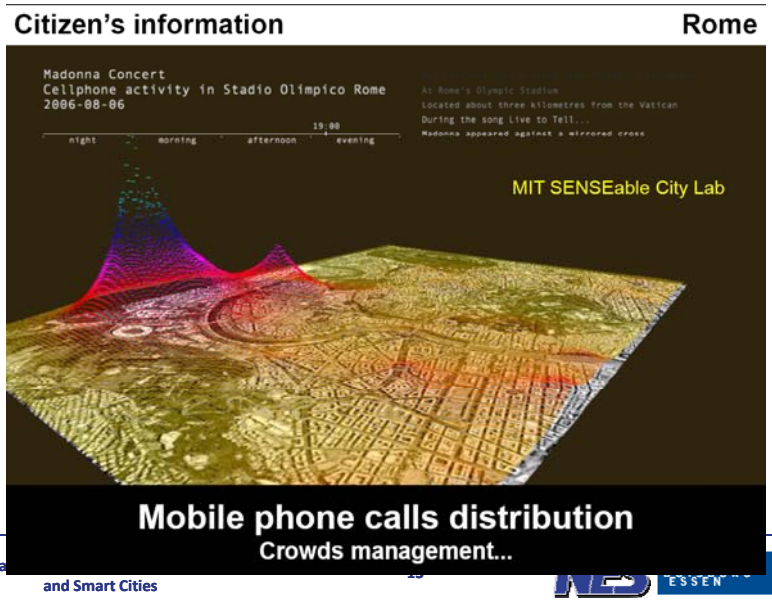
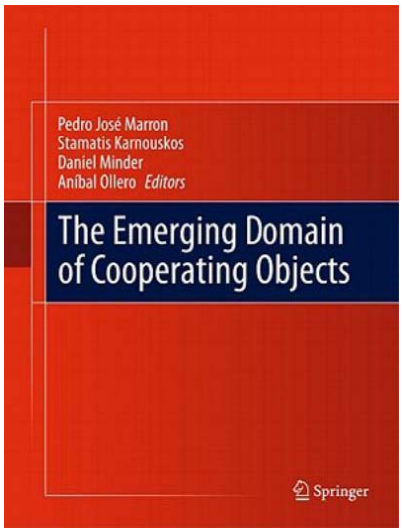


Mobile Phones as Sensors

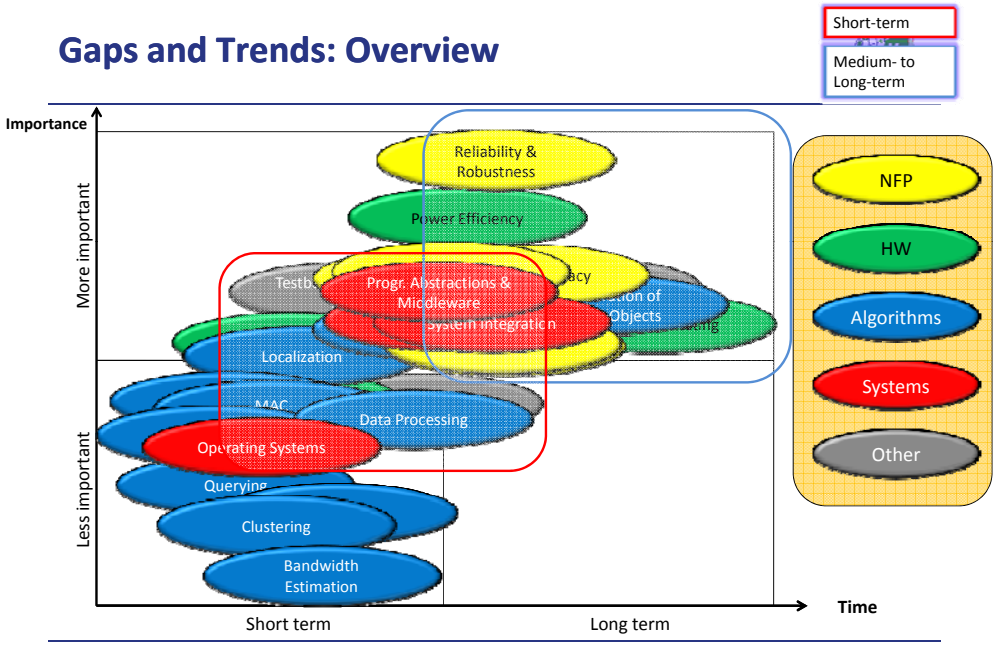


Research Roadmap on Cooperating Objects

- One of the main results of the Cooperating Objects Network of Excellence (CONET)
- First edition published by the European Commission
  - Updated every year
- State of the art for Cooperating Objects
- Current gaps and trends
- Main research topics and predominant work areas



Gaps and Trends: Overview



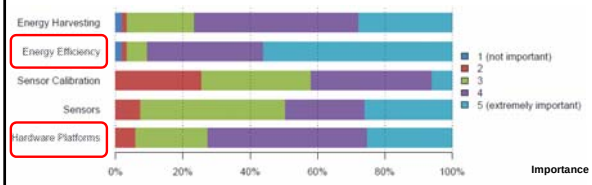
Some Fundamental Challenges

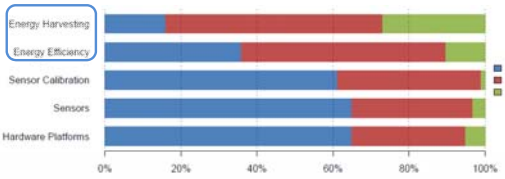
- Hardware-related
  - Energy harvesting
- Planning and Simulation
- Installation and System Integration
- Network Operation
  - Real-world conditions
  - Amount of generated data
  - Monitoring of the network
  - User interfaces
- Repairing and network healing

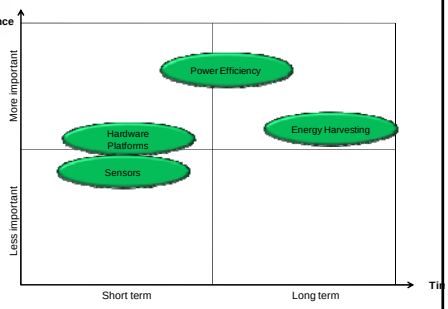
Gaps and Trends: Hardware

Short-term

Medium- to Long-term

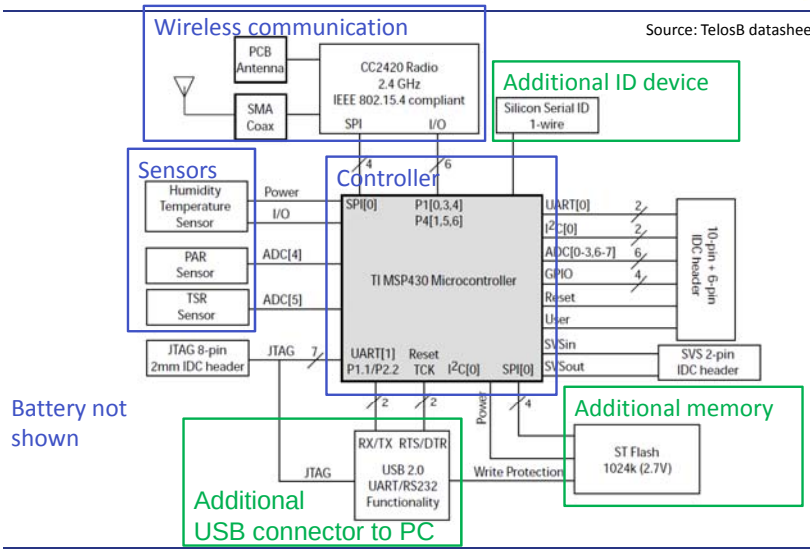






Example: TelosB

Source: TelosB datasheet, moteiv



Example Sensor Platforms

- TelosB (Crossbow)
  - Texas Instruments MSP430, 8 MHz
  - Chipcon CC2420, 2.4GHz
  - 10kB RAM
  - 48kB Program Flash
  - 1MB external Flash
- IMote2 (Crossbow)
  - Marvell PXA271 ARM
  - TI CC2420 802.15.4 / ZigBee compliant radio
  - 32MB SDRAM
  - 32MB Flash

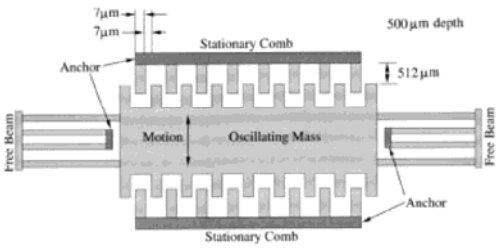
TelosB

Imote2

Energy Scavenging

[Paradiso, 2005]

- Light → solar cells: between 100 µW/cm² (office desk) and 100 mW/cm² (direct sun)
- Temperature gradients: 60 µW/cm² from 5K difference
- Acoustic noise: 0.003µW/cm² at 75 dB
- Vibrations: between 4 and 800 µW/cm³
- Pressure variation (piezo-electric): 330 µW/cm² from the heel of a shoe
- Air/liquid flow: 1mW/cm²



Power Consumption

[Landsiedel, 2005]

- Consumption depends on power mode of devices
  - power safe modes of CPU
  - transmit power levels of radio
  - different sensors
- Mica2 with CPU on and radio receiving draws 16mA

Device	Current	Device	Current
CPU		**Radio** (900 MHz)	
Active	7.6 mA	Core	60 μA
Idle	3.3 mA	Bias	1.38 mA
ADC Noise	1.0 mA	Rx	9.6 mA
Power down	116 μA	Tx (-18 dBm)	8.8 mA
Power Save	124 μA	Tx (-13 dBm)	9.8 mA
Standby	237 μA	Tx (-10 dBm)	10.4 mA
Ext Standby	243 μA	Tx (-6 dBm)	11.3 mA
		Tx (-2 dBm)	15.6 mA
LED (each)	2.2 mA	Tx (0 dBm)	17.0 mA
		Tx (+3 dBm)	20.2 mA
Sensor Board	0.7 mA	Tx (+4 dBm)	22.5 mA
		Tx (+5 dBm)	26.9 mA

- With standard batteries (2500mAh) it could run for 6.5 days
  - use of sleep modes, turn off radio, sensors, … if possible
  - process (i.e. compress, aggregate) data before transmitting

Cooperating Objects Hardware







Some Fundamental Challenges

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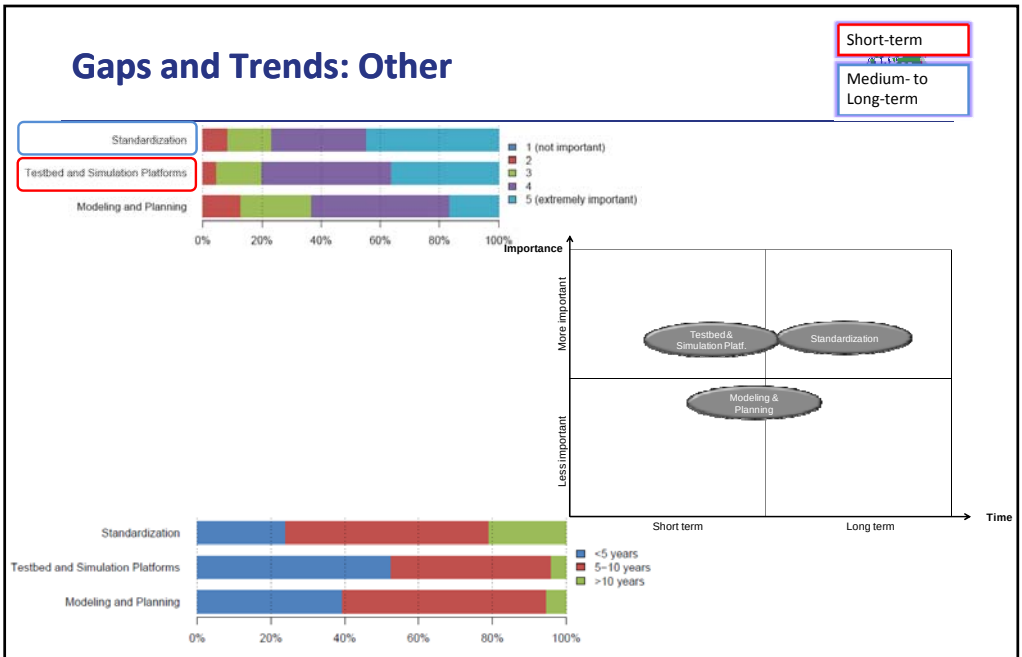
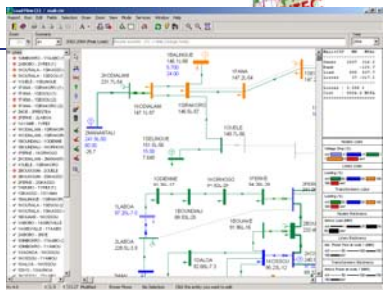
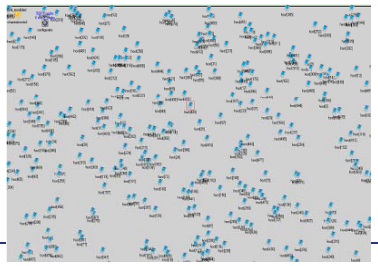
Gaps and Trends: Other

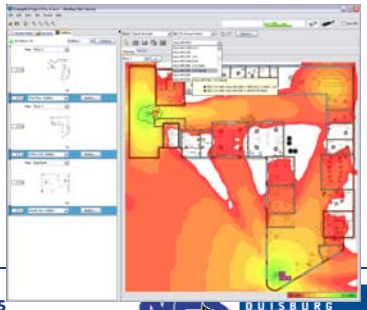


Planning / Simulation

- Topology constraints
- Coverage of the area
  - Sensing range ≠ communication range
- Change in environmental conditions

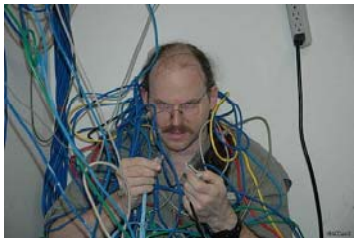


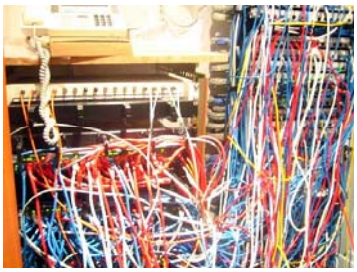




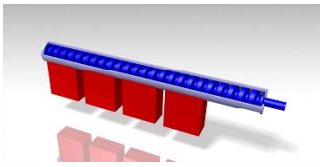
Installation

- Not a computer science problem
  - Tools are critical
- Maintenance is the key problem
- Integration with existing systems





Installation



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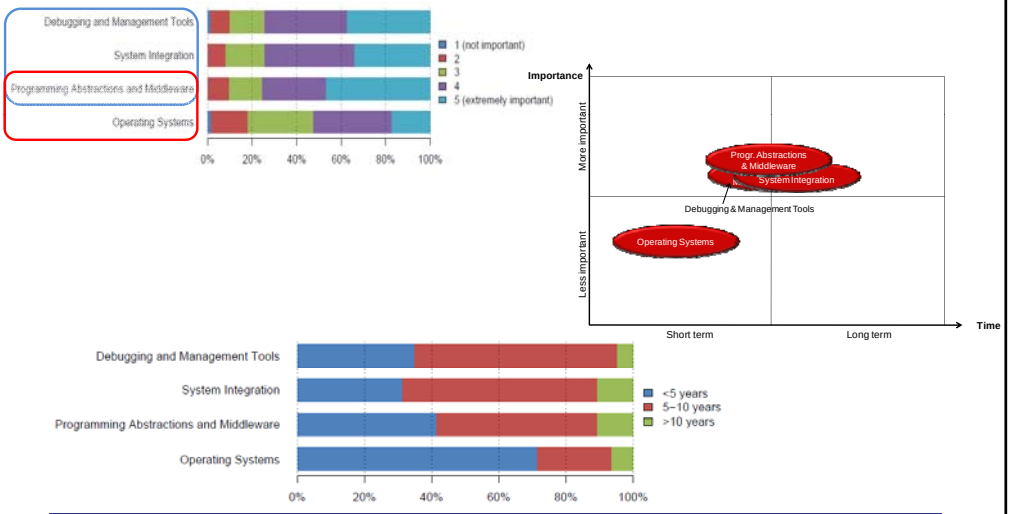
Gaps and Trends: Systems

Short-term

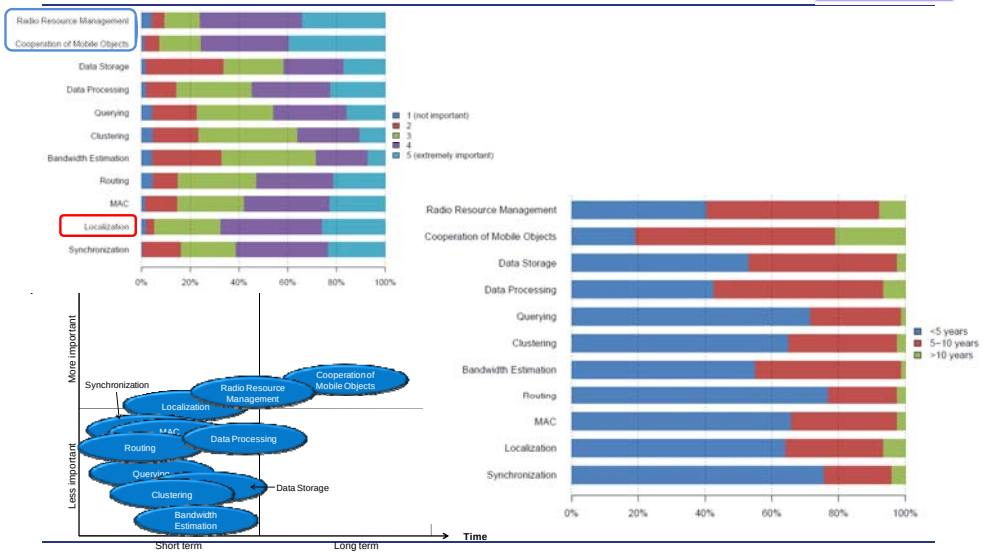
Medium- to Long-term



Gaps and Trends: Algorithms

Short-term

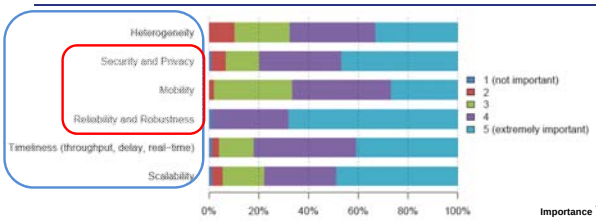
Medium- to Long-term

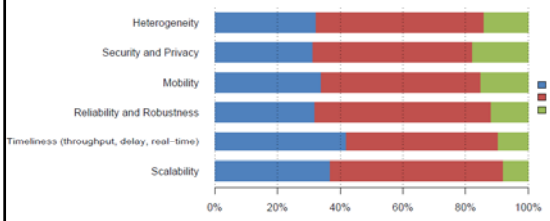


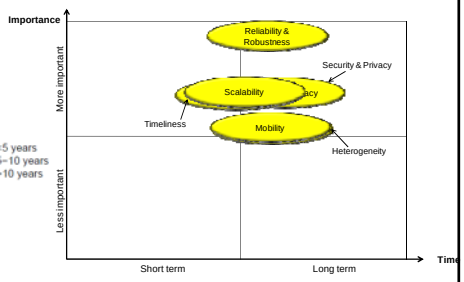
Gaps and Trends: NFP

Short-term

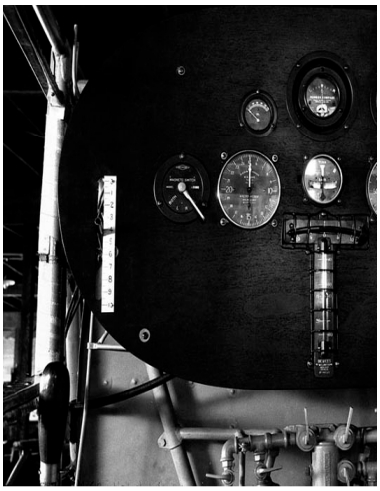
Medium- to Long-term







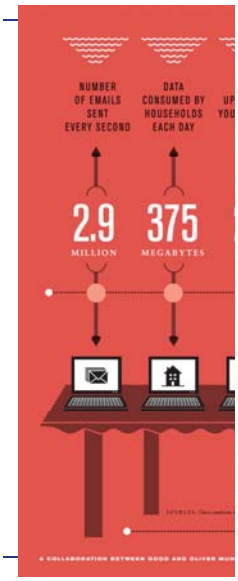
Network Operation



The Spirit of St. Louis (1927)
Source: www.charleslindbergh.com

Airbus A380 (2005)

Main Limiting Factors of Ubiquity



Eric Schmidt: Every 2 Days We Create As Much Information As We Did Up To 2003

MG SIEGLER | Wednesday, August 4th, 2010 | 2 Comments

Today at the **Techonomy** conference in Lake Tahoe, CA, the first panel featured Google CEO **Eric Schmidt**. As moderator David Kirkpatrick was introducing him, he rattled off a massive stat.

Every two days now we create as much information as we did from the dawn of civilization up until 2003, according to Schmidt. That's something like five exabytes of data, he says.

Let me repeat that: we create as much information in two days now as we did from the dawn of man through 2003.

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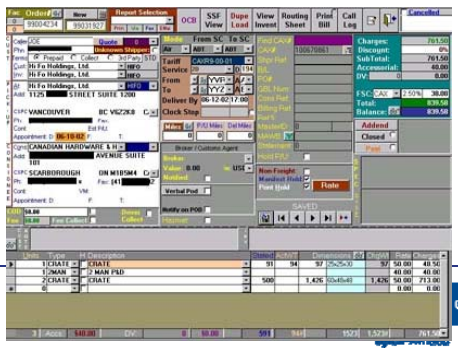
UNIVERSITÄT DUISBURG ESSEN

User Interface Design

- Ubiquity makes it hard
- Millions of embedded devices
  - On/off button?



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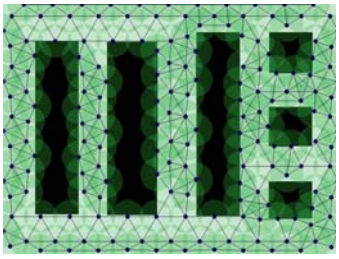
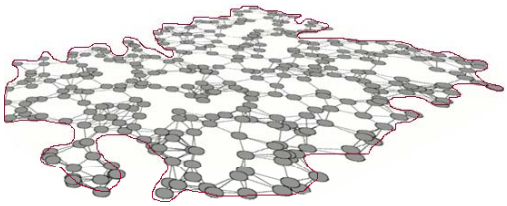
Network Repairing / Healing

- Detection of borders and holes is crucial
- Non-intrusive monitoring needed





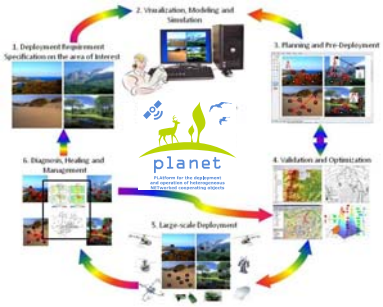
PLANET: PLAtform for the deployment and operation of heterogeneous NETworked Cooperating Objects

EU-FP7 Integrated Project

PLANET Objectives and Approach

The design, development and validation of an integrated platform to enable the smarter deployment, cost effective operation and maintenance of large scale complex systems of heterogeneous networked Cooperating Objects, including Wireless Sensor and Actuator Networks and mobile objects.

Objectives
O1: Design and development of the PLANET platform
O2: Methods for adaptive network deployment
O3: Autonomous systems for deployment
O4: Distributed network-centric computing
O5: Security methods
O6: Validation DBR
O7: Validation Airfield



PLANET Experimental Facilities

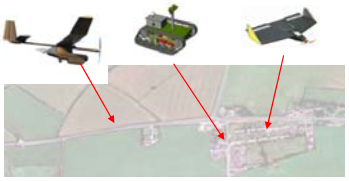
Environment:
Doñana Biological Reserve

Declared World Heritage Site in 1994. Part of the EU Large Scale Facilities.

Critical infrastructures and vehicles:
Airfield Scenario

New UAV airfield facility (4.1 M euros) for Air Traffic Management and UAV experimentation.

Other case study Scenarios



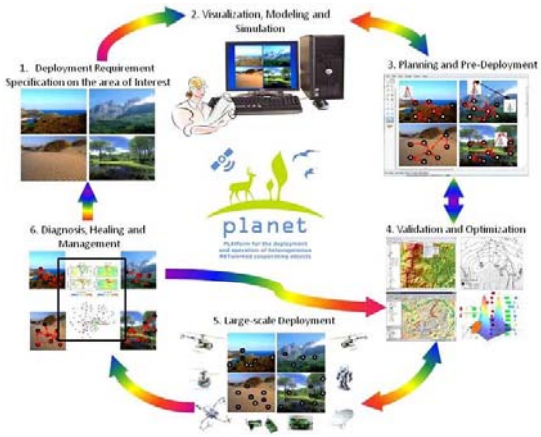
Saturn Scenario, Grand Challenge **, UK Bavarian** forest monitoring

PLANET Metadata

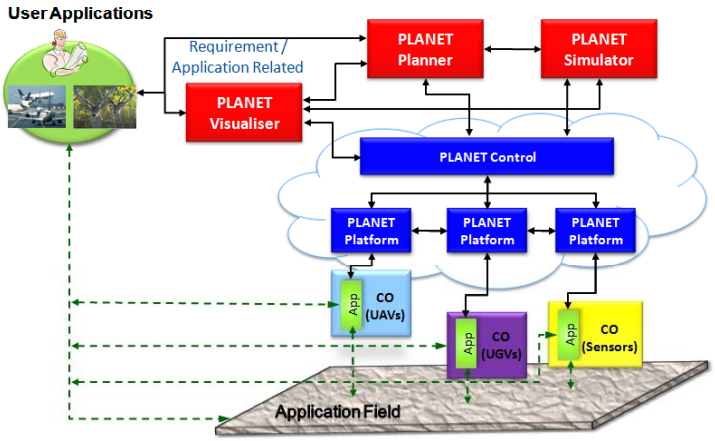
- Integrated Project with number INFSO-ICT- 257649
- Start: October 1st, 2010, End: September 31st, 2014, Duration: 48 months
- EC approved funding: 4.9 Mio. €
- Total Budget: 6.95 Mio. €
- Partners:
  - 7 academic partners
  - 5 industrial partners

planet
PLAtform for the deployment and operation of heterogeneous NETworked cooperating objects

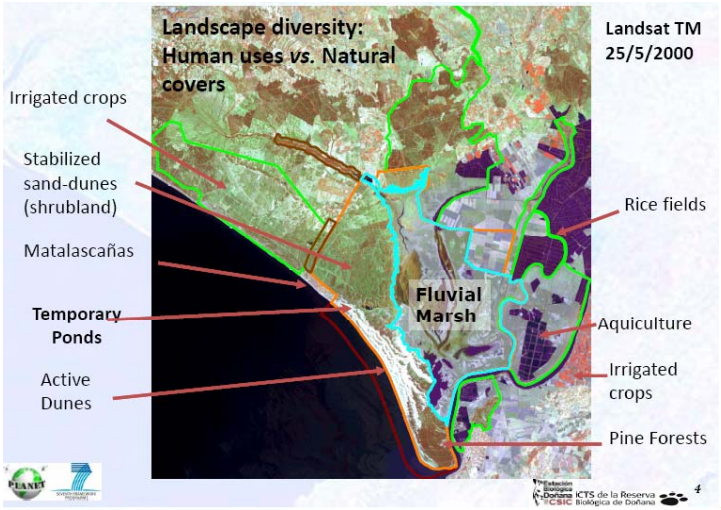
PLANET Approach



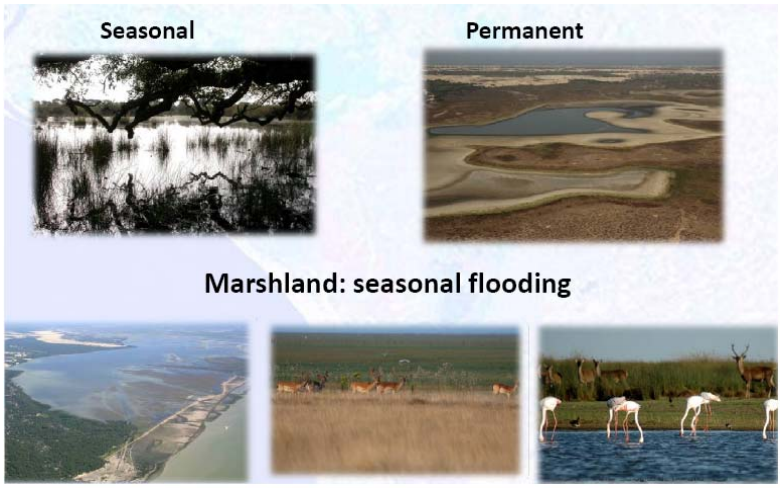
PLANET Architecture



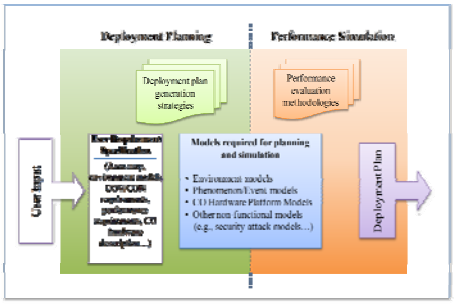
Doñana scenario

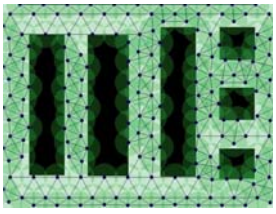


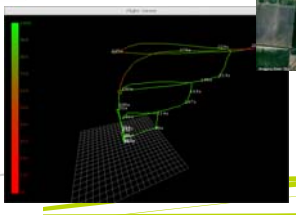
Doñana scenario

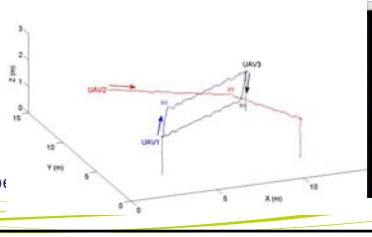


Planning and Simulation



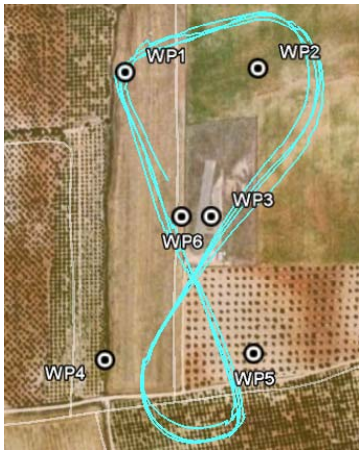






ICTS Infrastructure at Doñana

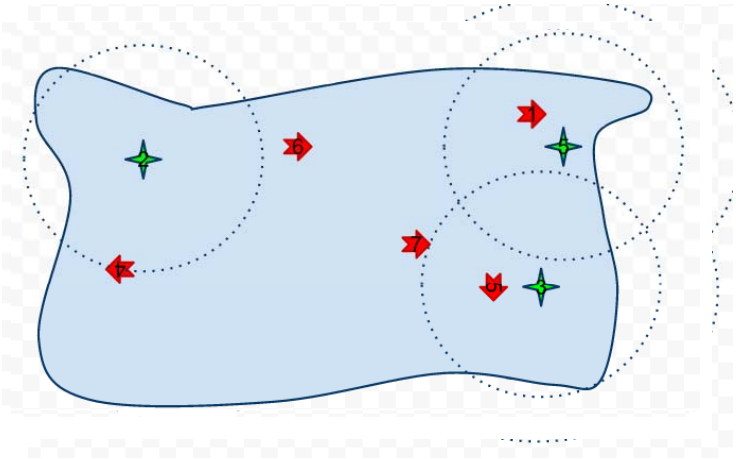
Effect of Real-World Factors (Wind) in UAV Flights



Dealing with Real-World Factors

- **Node Grouping approach**
  - **Suboptimal solution:**
    - Ensure a level of performance for data collection
    - Nodes grouping: UAV collects groups of WSN nodes
    - Consider UAV constraints and wind disturbances for UAV planning
  - **Trajectory computation is divided in two steps:**
    - Grouping of deployed nodes defining UAV collection zones
    - Computation of robust UAV trajectory to traverse the collection zones

Cooperative surveillance with Unmanned Aerial Systems



Doñana applications

- Pollution monitoring
- Monitoring of groups of animals
- Analysis of transmission of diseases
- Document of Grey Goose
- Aerial stratification of bats and insects

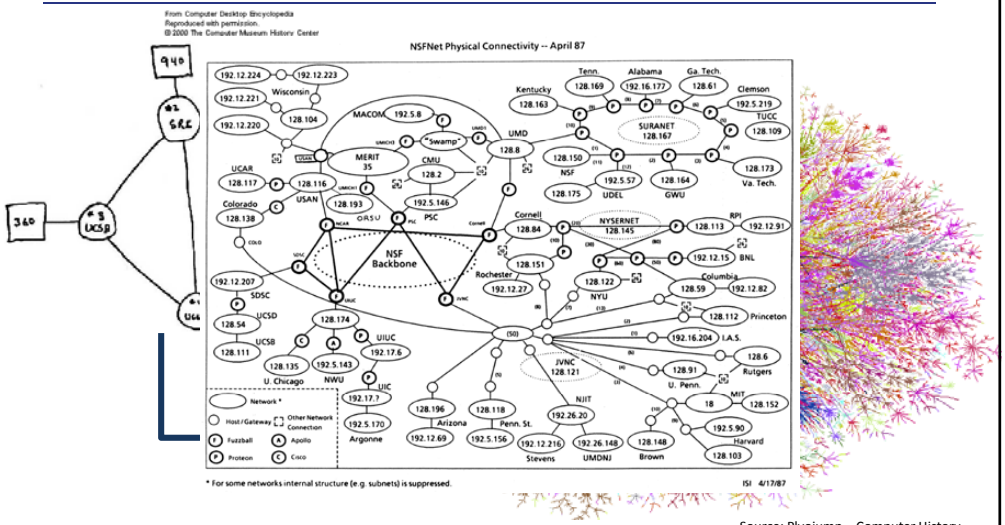
Pollution monitoring application

- These situations could be:
  - Episodes of water pollution by pesticides from agricultural activities in the environment: heavy metals, nitrates, phosphates...
  - Untreated water from nearby towns to the environment.
  - Toxic algae blooms, which can cause mass mortality of fish and birds.

Pollution monitoring scenario

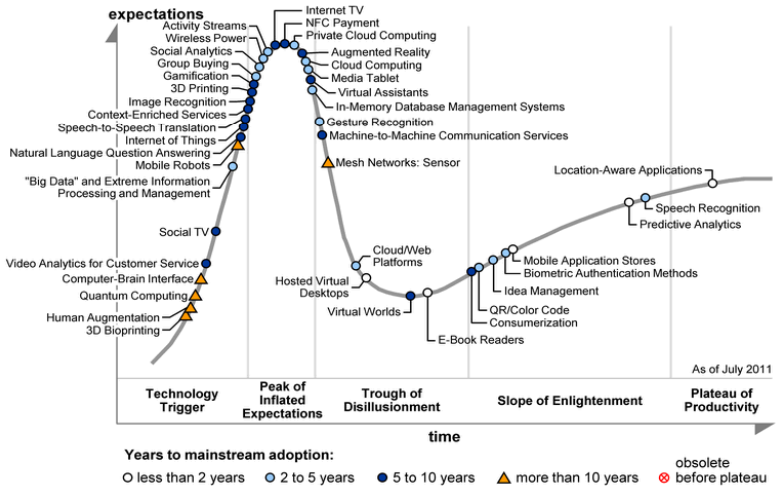
- **Scenario:**
  - **Very large (km²)**
  - **Difficult accessibility (marshland)**
  - **Global information as well as detailed information**
- **PLANET functionalities:**
  - **Surveillance with Unmanned Aerial Systems**
  - **WSN deployment with Unmanned Aerial Systems**
  - **WSN data collection with Unmanned Aerial Systems**
  - **Pollution sampling using Unmanned Aerial Systems**

Comparison to "normal" Internet



Source: Plyojump – Computer History

Lots of Hard Work Ahead



Source: Gartner 2011

Are We Ready to Go Large-Scale?

Not yet but we are getting there!

Thank you for your attention!