Two WSAN testbed projects

…and their extension into the future

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Overview

- Two projects addressing objectives under FP7-ICT Challenge 1:
  "*Pervasive and trustworthy network and service infrastructures*"
  - **WISEBED STREP** (**Wireless Sensor Network Testbeds**)
    - Objective: "*New paradigms and experimental facilities*"
    - 9 partners from 6 European countries
    - June 2008 – May 2011
  - **SENSEI IP** (**Integrating the Physical with the Digital World**)
    - Objective: "*The network of the future*"
    - 19 partners from 11 European countries
    - Jan 2008 – Dec 2010
- Complementary nature of the two projects
- Integration of the two to seed a new *Internet of Things (IoT) testbed* that will facilitate future IoT/FI/RWI experimentation
  - **SmartSantander IP**, starting in September 2010
  - Addresses Challenge 1, objective ICT-2009.1.6:
    "*Future internet experimental facility and experimentally driven research*"

Complementary nature of the two projects

- WISEBED
  - *Systems level* abstraction over instances of WSANs and their constituent nodes
- SENSEI
  - *Application level* abstraction that integrates multiple WSAN instances and adds semantic and contextual services
- Both are essential components of a comprehensive “Internet of Things” testbed
- First, let’s look at WISEBED…

WISEBED…

Partners in the WISEBED project

- Institute of Telematics, Universität zu **Lübeck**, Germany (Coordinator)
  - Prof. Stefan Fischer, Dr. Dennis Pfisterer
- Computer Systems & Telematics Group, Freie Universität **Berlin**, Germany
  - Prof. Jochen Schiller, Prof. Mesut Günes
- Algorithms Group, **Braunschweig** Institute of Technology
  - Prof. Sándor P. Fekete, Dr. Alexander Kröller
- Research Academic Computer Technology Institute, **Patras**, Greece
  - Prof. Paul Spirakis, Dr. Ioannis Chatzigiannakis
- Software Department, Universitat Politecnica de Catalunya, **Barcelona**, Spain
  - Prof. Josep Diaz
- Computer Networks and Distributed Systems, Universität **Bern**, Switzerland
  - Prof. Torsten Braun
- Centre Universitaire d'Informatique, University of **Geneva**, Switzerland
  - Prof. José Rolim
- Parallel and Distributed Systems Group, **Delft** University of Technology, Netherlands
  - Prof. Koen Langendoen
- Computing Department, **Lancaster** University, UK
  - Prof. Geoff Coulson

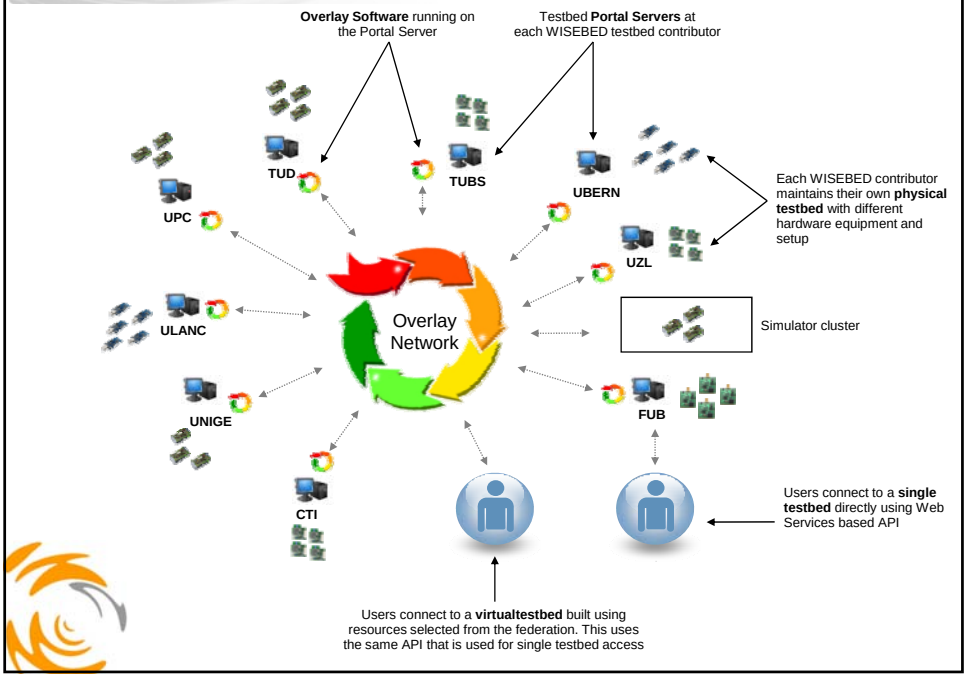
Each runs its own WSAN testbed – federate them into a useful extensible facility?

The WISEBED approach

WISEBED

- Goal: To enable the evaluation and testing of WSAN systems and applications at large scale with great flexibility
- Approach
  1. Federate individual per-site testbeds via the Internet
     - Promotes heterogeneity and scalability
  2. Support the whole of the experimentation lifecycle
     - Design, simulate, deploy, monitor, reconfigure, post-mortem
  3. Mix *physicality*, *emulation* and *simulation*
     - Offer interactive access to per-user "**virtual testbed**" instances
     - Virtual testbeds selectively combine (portions of) physical testbeds with emulated and simulated testbed elements
  4. Offer value-added services
     - A **software development kit** that accommodates node heterogeneity and supports dynamic reconfigurability
     - A **library** of useful algorithms, mechanisms and protocols
     - An **archive** of data traces of real-life situations and environments to aid meaningful experimentation (e.g. repeatability)

Federated architecture



Let's build a virtual testbed…

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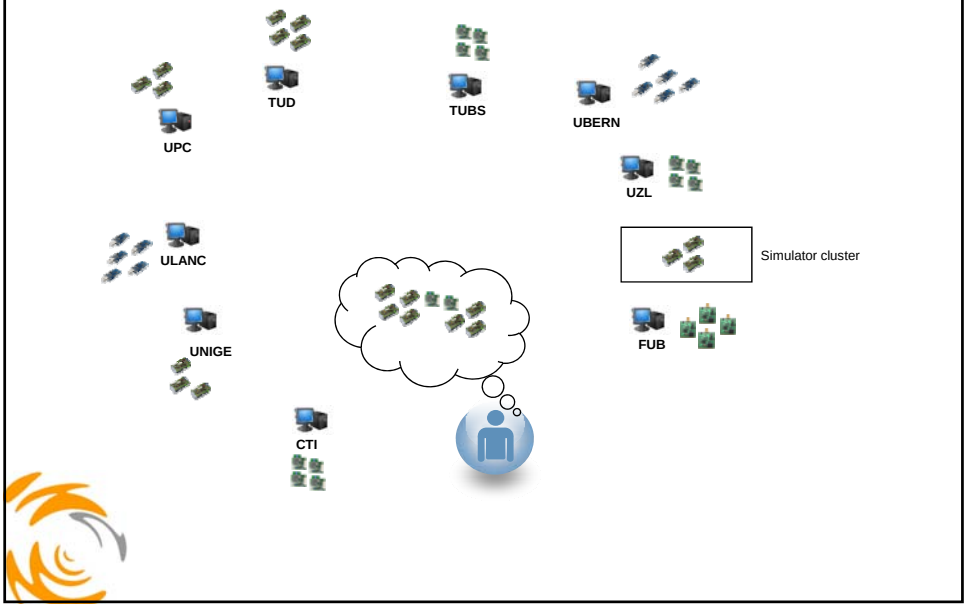

Let’s build a virtual testbed…

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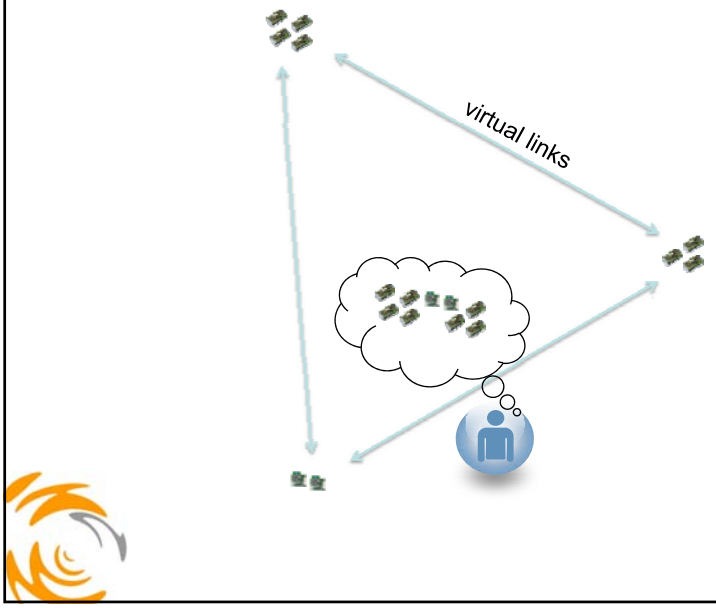

Let’s build a virtual testbed…

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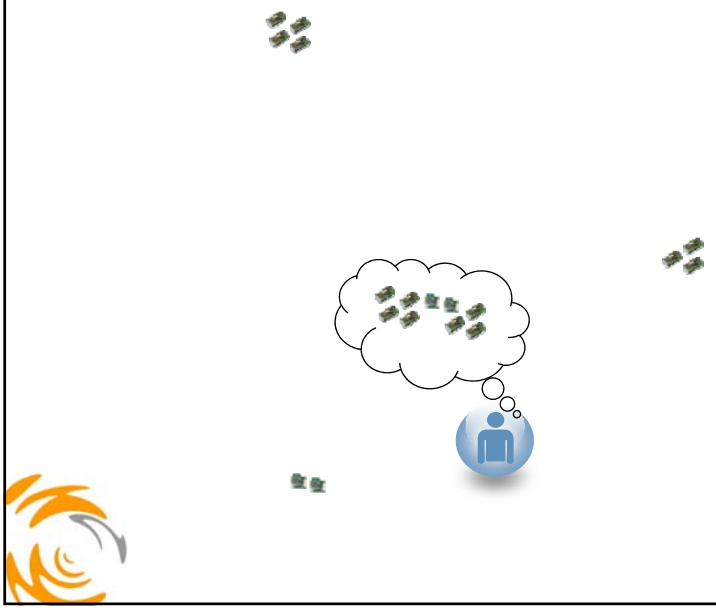


Benefits of virtual testbeds

- Can virtualise the following testbed elements
  - (Scale and heterogeneity)
  - Sensor input/ actuator output
  - Sensor/actuator nodes
  - Node connectivity/network topology
  - Power
  - Mobility
- Enable radical flexibility
  - Exploit physicality where needed
    - e.g. Real-world sensor input, radio characteristics, execution overheads…
  - Employ emulation/ simulation where physicality is unwanted or impossible
    - To enable arbitrary connectivity patterns/ topologies; feed virtual inputs to real sensors; explore WSAN lifetimes; reduce experiment execution time; explore mobility in a repeatable manner…
  - Enable cost/ accuracy trade-offs
    - Bias towards physicality to increase accuracy
    - Bias towards emulation/ simulation to reduce cost

Current status

- ✓ Each partner's testbed is accessible via their Portal Server which runs a standard Web Services based API for control/management
- ✓ Can manage any testbed interactively via a GUI front end
- ✓ XML dialects to describe both testbed structure and sensor data
- ✓ Software development kit running on all supported platforms (based on the 'OpenCom' software component model)
- ✓ Well-populated WISELIB algorithm library
- ✓ Started to use WISEBED for real experimentation
- ⊦ 'Manual' approach to define and instantiate virtual testbeds

- Future work
  - GUI-based assistance for virtual testbed definition and instantiation
  - Support early-adopter external users and testbed contributors
  - Harden and document in preparation for general release at end of project

2 years into a 3 year project

SENSEI…

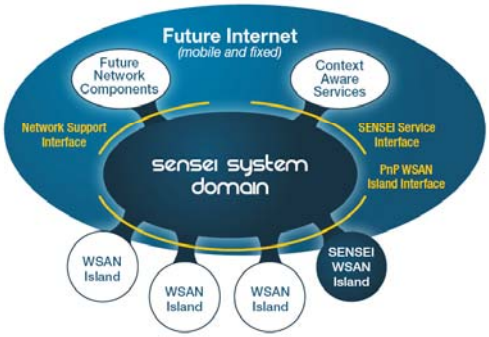
(n.b. this will necessarily be a non-authoritative description!)

Partners in the SENSEI project

- CEA-LETI, France
- The University of Surrey, UK
- ALMA, France
- Arup, UK
- Ericsson, Sweden and Serbia
- NEC, UK (Germany)
- SAP, Germany
- Telefónica, Spain
- Thales, UK
- Ambient Systems, Netherlands
- Sensinode, Finland
- Consorzio Ferrara Ricerche, Italy
- ETH Zurich, Switzerland
- University Politehnica of Bucharest, Romania
- University of Oulu, Finland
- Université Pierre Mendès France, Grenoble, France
- University of Twente, Netherlands

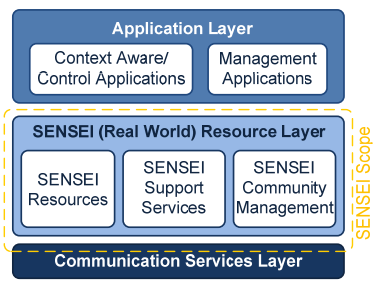
SENSEI vision and goals

- Overall goal is to facilitate the integration of the physical and digital worlds
- Interconnected sensors and actuators deployed everywhere
  … by individuals, companies, and WSN operators
- Sensors and actuators easily accessible and controllable as a *resource pool* via a global framework of standardised interfaces
- An “open market“ for digital interaction with the physical world

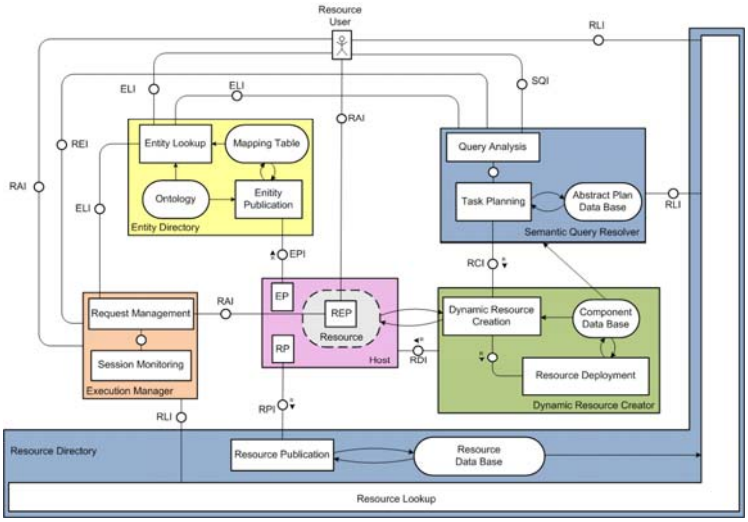


Main architectural elements

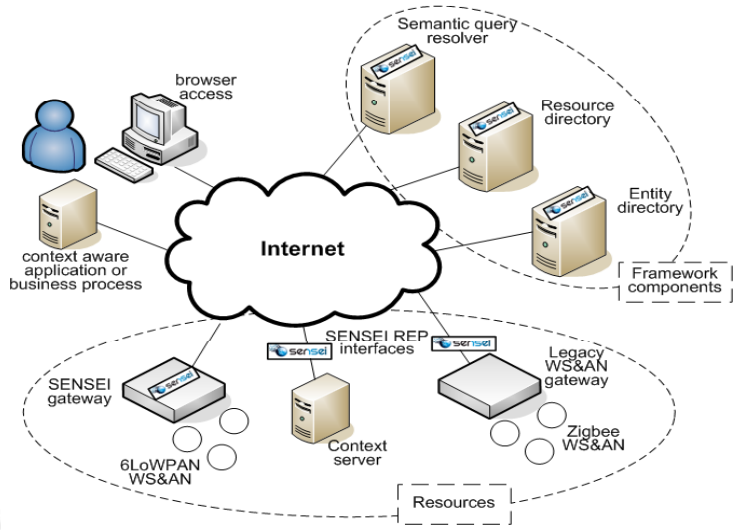
- *Resources*:standard wrapper for heterogeneous devices (sensors, actuators, processors, managers); may run on separate host to physical device; XML-based resource description
- *Entities*: representations of people, places and things
- *Support services*: resource and entity directories, semantic query resolver, long-term execution manager etc.
- *Community management* elements: account and identity management, security and privacy etc.



SENSEI elements in detail



SENSEI's Pan-European testbed (PET) implementation



Current status

- PET is being used to support several field trials
  - Mobile Environment Monitoring
    - Sensors fitted to buses/trams in Belgrade provide data that is used by multiple applications to inform transport operators and users about pollution, delays and road conditions
  - Smart Places
    - Sensors/actuators fitted within an office building are used to manage meeting rooms, assist visitors, conserve energy and enforce security policies
  - Smart Cities
    - A legacy system (COOS) capable of city-wide sensing/actuation is integrated with SENSEI to develop new context-aware services
  - Access Control
    - A physical security-based trial where control of an actuator (camera) is shared among more than one application in a horizontalised re-use case
- Looking for new WSAN islands to add…

2.5 years into a 3 year project

SmartSantander…

(n.b. project start subject to final contract negotiations)

Partners in the SmartSantander project

- Telefónica I+D, Spain s
- Alcatel-Lucent s.p.a, Italy
- Alcatel-Lucent S.A, Spain
- Ericsson d.o.o, Serbia s
- TTI Norte, Spain
- Universidad de Cantabria, Spain
- University of Surrey, UK s
- Universität zu Lübeck, Germany w
- Lancaster University, UK w
- CEA, France s
- Computer Technology Institute, Greece w
- Alexandra Instituttet A/S, Denmark
- Santander Council, Spain
- Sociedad para el Desarrollo de Cantabria, Spain
- University of Melbourne, Australia

SmartSantander vision and goals

- Large-scale pan-European testbed for experimentation with IoT technologies, architectures, and applications
  - Real-life deployment in Santander (and elsewhere)
  - Deployment in rich urban settings and encompassing key societal interests – such as transport, work places, public spaces, hospitals, universities, tourist sites (prehistoric caves)
- Provide a European innovation hub for IoT, and complement other FIRE facilities
  - Aimed at researchers, service providers and end-users
- Assessment of the impact of the IoT on network infrastructures - to facilitate design and testing of future network capabilities
  - The real requirements of IoT/FI/IoS etc. in terms of network capacities, resources and services are unknown, due to insufficient deployment
- Assessment of social acceptance of IoT technologies and services
  - Enable experimentation with real users under realistic conditions

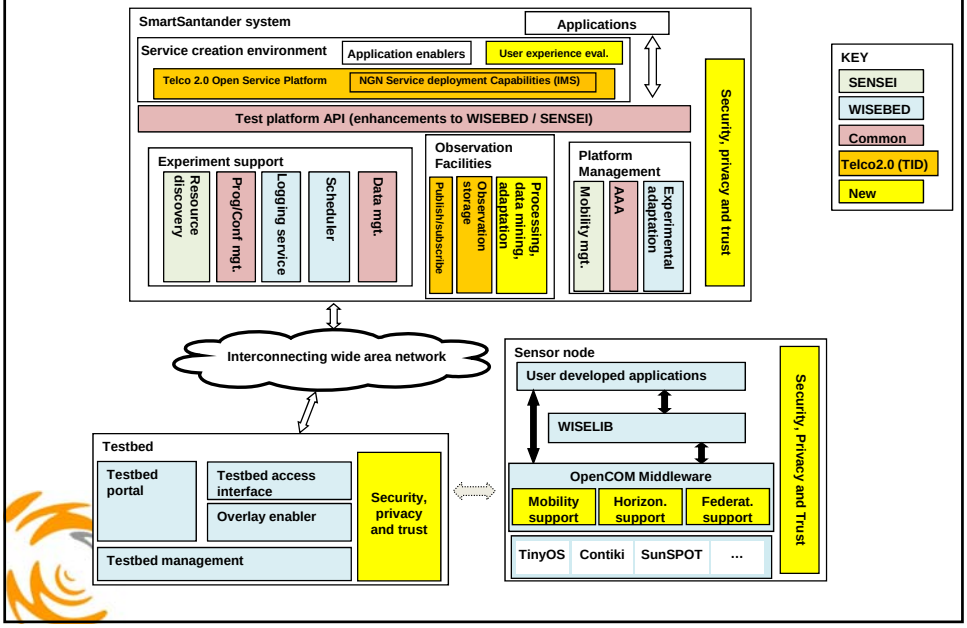
Target of 20K IoT devices, 12K of which will be in Santander

Contributions from WISEBED and SENSEI

- WISEBED
  - Per-site testbed access API
  - Sensor node SDK and node runtime
  - WISELIB algorithm library
- SENSEI
  - High-level platform API
  - Semantic and contextual tagging
  - Generalised resource discovery, access and control
- Telco 2.0 Open Service Platform (from Telefonica)
  - Service deployment

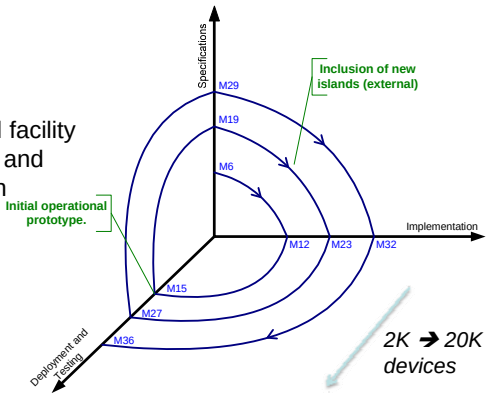
- New elements
  - Integrated platform API
  - Integrated AAA approach + privacy,trust and confidentiality
  - Comprehensive mobility support
  - Data mining
  - Federation with external facilities
  - User experience evaluation
  - *Horizontality* (support of different applications on common infrastructure)
  - *Verticality* (support for testing at all layers of the testbed)

Initial architecture



Workpackages, phases and open calls

WP 0: Project management
WP 1: Reference model
WP 2: Specification and design
WP 3: Building the experimental facility
WP 4: Development, evaluation and impact of use cases for research community and end-users
WP 5: *Experimentation support, dissemination and sustainable exploitation*



- Budget includes resources for *open calls* for innovative user experiments
  - €1.5M (approx) = 160 person-months
  - For use by researchers from outside the project
  - Results to be used as feedback to improve the facility further
  - Scheduled in middle phase between months 15 and 27

Conclusions

- WISEBED and SENSEI are complementary projects in the WSAN domain
- Both are key feeders to the upcoming SmartSantander pan-European IoT/FI/IoS testbed
- Centred on a rich urban environment in Santander, Spain; and supporting real user-based trials
- Aimed at researchers, service providers and end-users
- Planned open calls for funded experiments – first call should be opening around January 2012

Thank you

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