

“SMART CITIES, the silent IoT revolution”

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“Smart Cities, the silent IoT revolution”

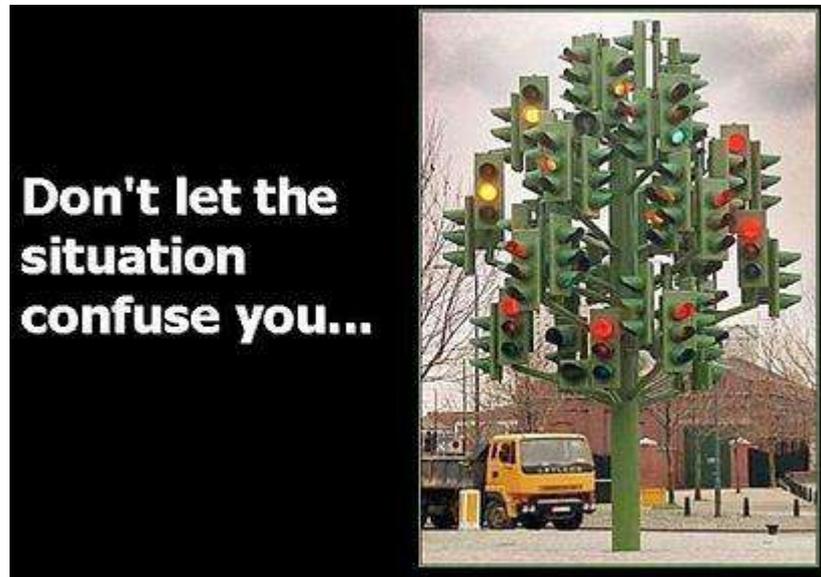
More than half of the World’s population live nowadays in cities. Moreover, this proportion is day by day increasing. Besides, and as urban environments are becoming denser and more complex, cities face problems in many different areas, some of them related to information services, urban mobility, and energy efficiency. Fortunately, it is in the city context where a limited investment in ICT infrastructures can be more easily streamlined, benefiting both citizens and municipalities.

From a practical point of view, a big opportunity lies currently on the utilization of the innovative IoT technologies developed in recent years to improve the quality of life of the citizens. With these principles in mind, a number of initiatives with different multidisciplinary approaches are being currently developed worldwide at different locations. SmartSantander, overviewed in this talk, is one of the most remarkable ones.



1 What are Smart Cities about

The term 'smart' is frequently used with multiple different meanings!



Smart Cities have been recently pointed by experts as an emerging market with enormous potential, which is expected to drive the digital economy forward...

“The 19th century was a century of empires, the 20th century was a century of nation states, the 21st century will be a century of cities”

Wellington E. Webb, former mayor of Denver



By July 12, 2007 a United Nations report coinciding with World Population Day revealed that for the first time in history, more people now live in cities than rural areas...

Cities over the centuries

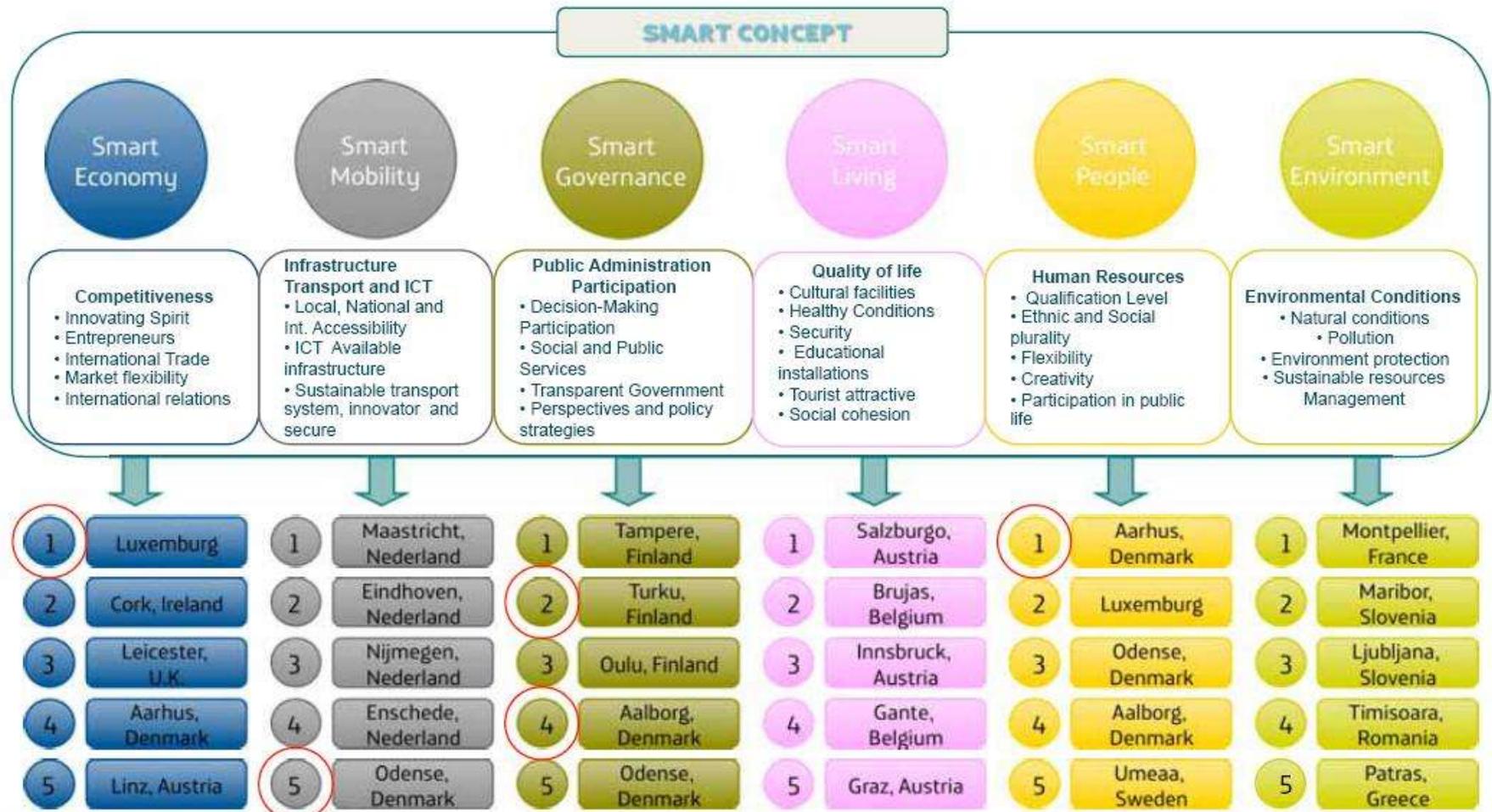
- The concept of 'smartness' is wide open, has changed over the time, and has a bunch of significances for different people



A city can be defined as 'smart' when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel **sustainable economic development** and a high quality of life, with a wise management of natural resources, through participatory governance



A ranking exercise (medium-sized cities): The six Axes of Smart City Development (2007)

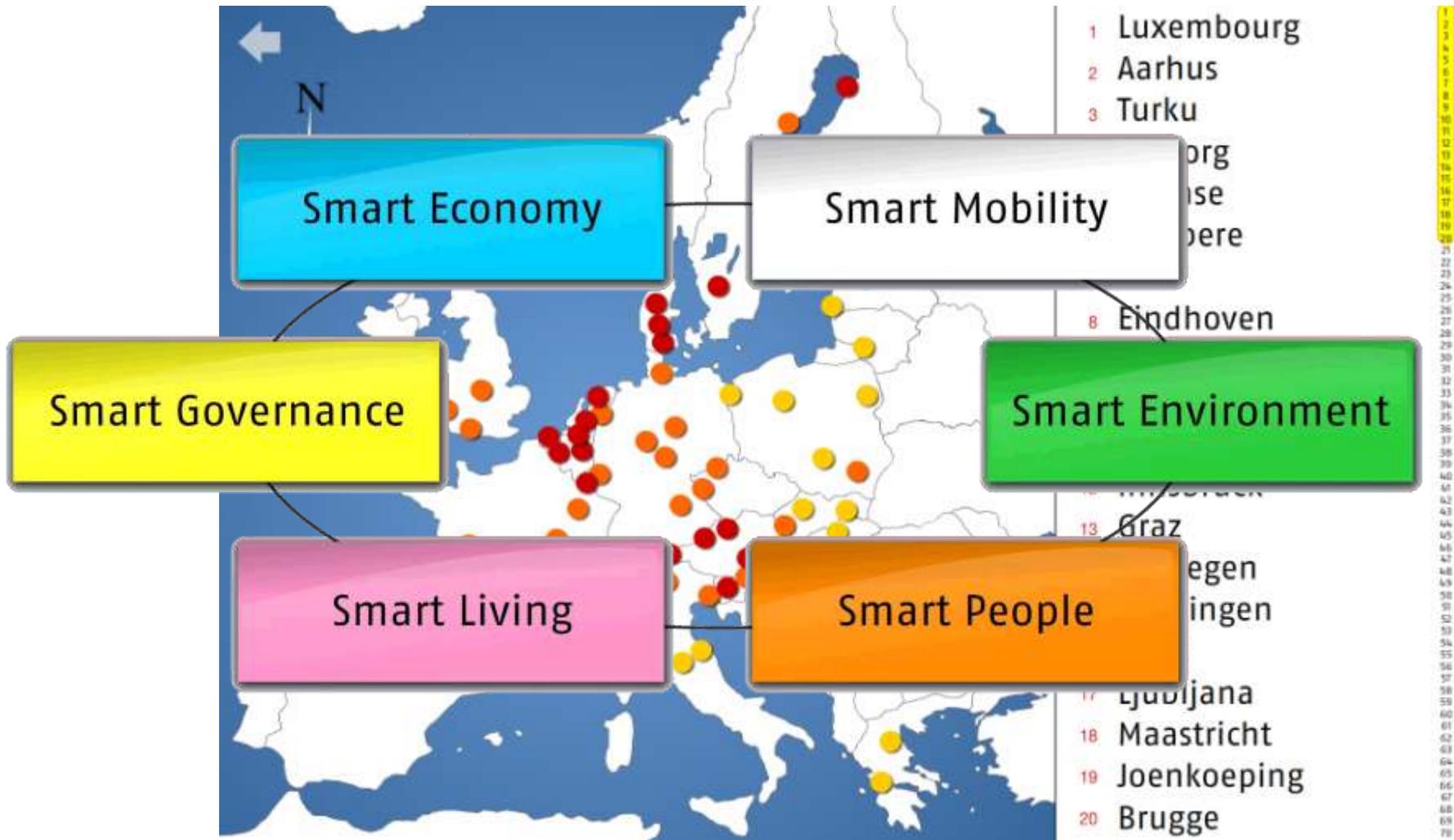


Note The red circle indicates those cities better positioned in the overall ranking in this order : 1. Luxemburg, 2. Aarhus, Denmark 3. Turku, Finland 4. Aalborg, Denmark, 5. Odense, Denmark

Source: Smart Cities, Ranking of European medium-sized cities. Technological University of Vienna, University of Ljubljana and Technological University of Delft. 2007



But most cities worldwide are running new initiatives... ... and the landscape is changing continuously



Source: <http://www.smart-cities.eu/>



Cities all over the World: smart, dazzling, liveable?

The most livable cities in the world in 2008

1. Vancouver, Canada
2. Melbourne, Australia
3. Vienna, Austria
4. Perth, Australia
5. Toronto, Canada
6. Helsinki, Finland
7. Adelaide, Australia / Calgary, Canada
9. Geneva, Switzerland / Sydney, Australia / Zürich, Switzerland



Economist.com rankings

Liveability

Based on five broad categories: stability, healthcare, culture and education, and infrastructure. economist.com, April 28, 2008

Selected cities, 100=ideal, June-December 2008 (latest available)

Best

Rank		Liveability*
1	Vancouver	98.0
2	Vienna	97.9
3	Melbourne	97.5
4	Toronto	97.2
5	Perth	96.6
	Calgary	96.6
7	Helsinki	96.2
8	Geneva	96.1
	Sydney	96.1
	Zurich	96.1

Worst

Rank		Liveability
140	Harare	37.5
138	Algiers	38.7
	Dhaka	38.7
137	Port Moresby	38.9
136	Lagos	39.0
135	Karachi	42.1
134	Douala	45.4
133	Kathmandu	46.4
132	Abidjan	46.6
131	Dakar	46.8



Source: Economist Intelligence Unit



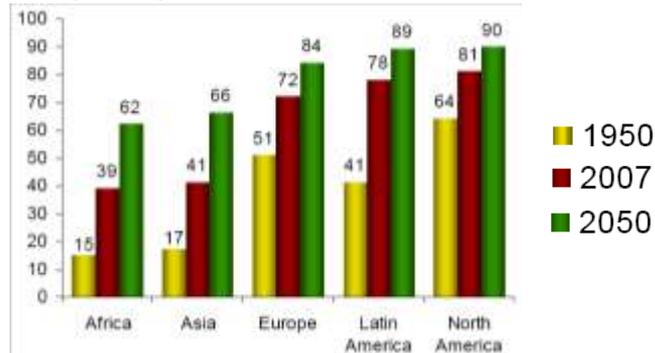
2 Socio-economic Context

Smart Cities, as growth engines of the modern economy, will play a key role in the future digital society

(Smart) Cities are a world-wide exploding trend for the next years; both from a technical and societal point of view...

Urbanization

Population in urban areas is projected to gain 3.1 billion, passing from 3.3 in 2007 to 6.4 billion in 2050*



Citizens

The profile of people living in cities is different and is rapidly evolving

- They are more **economical** successful
- They are more **educated**
- They are generally **healthier**

Cities

Cities are very complex living ecosystems with millions of transactions per day

- They have increasing **energy needs**
- They are able to provide a great variety of **goods and services**
- They produce **pollution and waste**
- They tend to be more **inefficient** in space & resources usage

Technologies

Cities are integrating more and more technology at all levels

- **Intelligent devices** (smart phones, intelligent sensors, interactive screens, etc.)
- Ubiquitous **broadband networks** to stay always connected
- **Analytics** and **social media** (real-time data and decision making, collaborative spaces, electronic media, etc.)



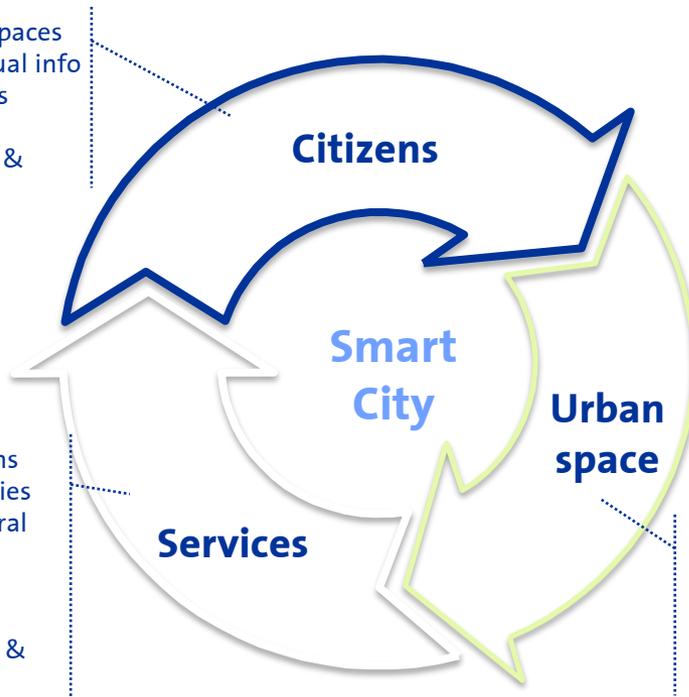
... but up till now most efforts have been dedicated to shape the Smart City vision

Definition

Economic: Smart Cities can be seen as digital platforms to maximise economic, social and environmental well-being, and to enable change towards more sustainable behaviour amongst all parts of a community, such as end-users, businesses and the cities' own administration

Technical: A Smart City is a new urban space which, provided with millions of sensors (including persons) and actuators, is able to "listen" and "comprehend" what is happening all over the city to thus make better decisions and provide the right information to its inhabitants

- Digital collaboration spaces
- Personalized/Contextual info
- Multi-modal interfaces
- Smart phone apps
- Collective Intelligence & Participation



- Online Services & Comms
- Information for 3rd Parties
- Real-time spacio-temporal city model
- Urban estimation & planning tools
- Remote City monitoring & configuration

Three steps towards a Smart City

- I Digitalization.** Installation (or conversion) of strategic points of measurement, monitoring and interaction throughout the city's urban space.
- II Modelization.** Process, interconnect and infer information from the new data collected both from the city and its inhabitants
- III Intelligence.** Analysis of the new available information to, in combination with already available sources of data, infer the best response and provide novel services to citizens and businesses

- Ad-hoc sensor networks
- Embedded systems
- Interactive tools
- Real-time control systems
- Urban computing

[Introducing the Smart City Video](#)
Smarter Planet, IBM Initiative



Some relevant initiatives in different application areas all over the World

**Colorado & Ohio
(SmartGrid)**

**Stockholm
(Emissions)**

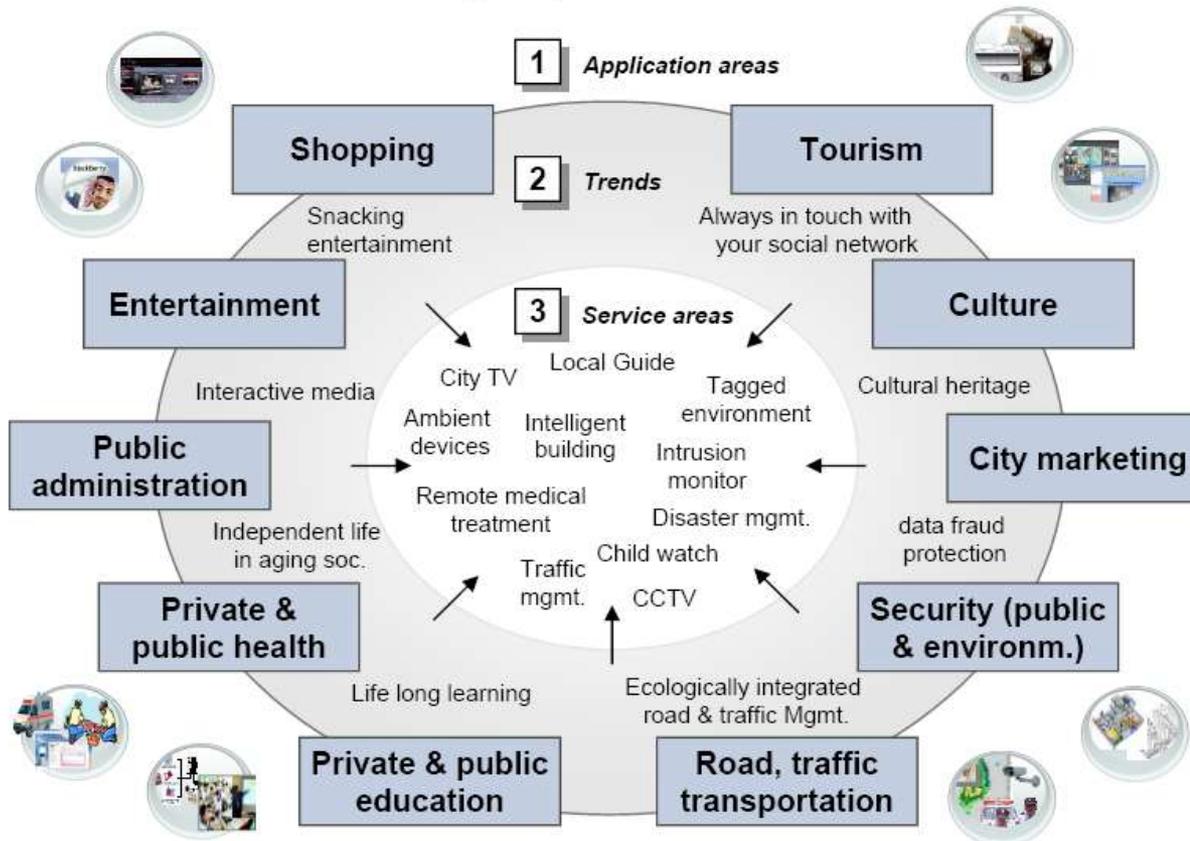
**Amsterdam
(SmartGrid)**

**Dubai, Malta, Kochi
(Business oriented)**



A new generation of services, more intelligent, personalized and ubiquitous will arise within cities & urban spaces... affecting many aspects in our lives

A holistic mega-city vision of tomorrow



1 Define application areas

- Identify relevant domains
- Align with existing initiatives
- Identify gaps

2 Identify trends

- Global trend analysis
- Local trend survey
- Identify implications

3 Specify service areas

- Prioritize service areas
- Specify business requirements
- Derive technical requirement

(*) Smart Cities. Detecom Consulting for Deutsche Telekom Group

Technology will be one of the key drivers to realize the Smart City vision

What makes a “smart city” smart is the combined use of software systems, server infrastructure, network infrastructure, and client devices

**Pervasive
broadband
networks**

... enabling real-time communications among intelligent devices and back-end systems

**Intelligent
devices**

... (e.g., smart phones, smart meters, sensors) providing cost effective “telemetry” for infrastructure, vehicles, people, etc.

**Smart
computing &
social media
process**

... to process real-time data streams, enable real-time decision making, and provide a platform for information dissemination and collaboration among citizens and all stakeholders



3 The European model

Smart Cities are on the lime light of most Public Institutions. The European Commission is promoting its development within the Future Internet context

The European Context for the Smart Cities



Photos: <http://www.agefotostock.com>



Photos: <http://www.agefotostock.com>



Features and elements of a “Smart City”

■ Instrumented

- Smart meters, distribution networks
- Building management systems
- Infrastructure sensors
- Traffic and transit sensors
- Public safety systems

■ Interconnected

- Networked environments – fibre, wireless, buildings, open spaces
- Networked sensors, sensor platforms, concentrators
- Enterprise Service Bus (ESB) – a platform to realise a service-oriented enterprise architecture

■ Intelligent

- Lots of data – how to get value from it?
- Real-time analysis of sensor data streams
- “Enterprise-view” visibility of the city in action
- Behavioural modelling of physical, natural and people systems,...



Source: IBM at Global Forum 2009, Bucharest, RO

Technological components for Internet enabled services in Smart Cities

■ Networked RFID tags and elements

- Passive and active tags partially interconnected
- Simple mobile devices

■ Sensor Networks

- Interconnected simple and multimodal sensors and actuators
- Partially build-in intelligence
- Complex mobile devices

■ Internet of Things

- Diverse identification technologies (Sensors, Biometrics, etc.)
- Intelligent Objects
- Distributed Intelligent Systems
- Sophisticated devices, clothes and materials

Future Internet-enabled services in “Smart Cities”, Gérald Santucci, EC, Jan 2010



Building blocks for Smart Cities

Internet-enabled services

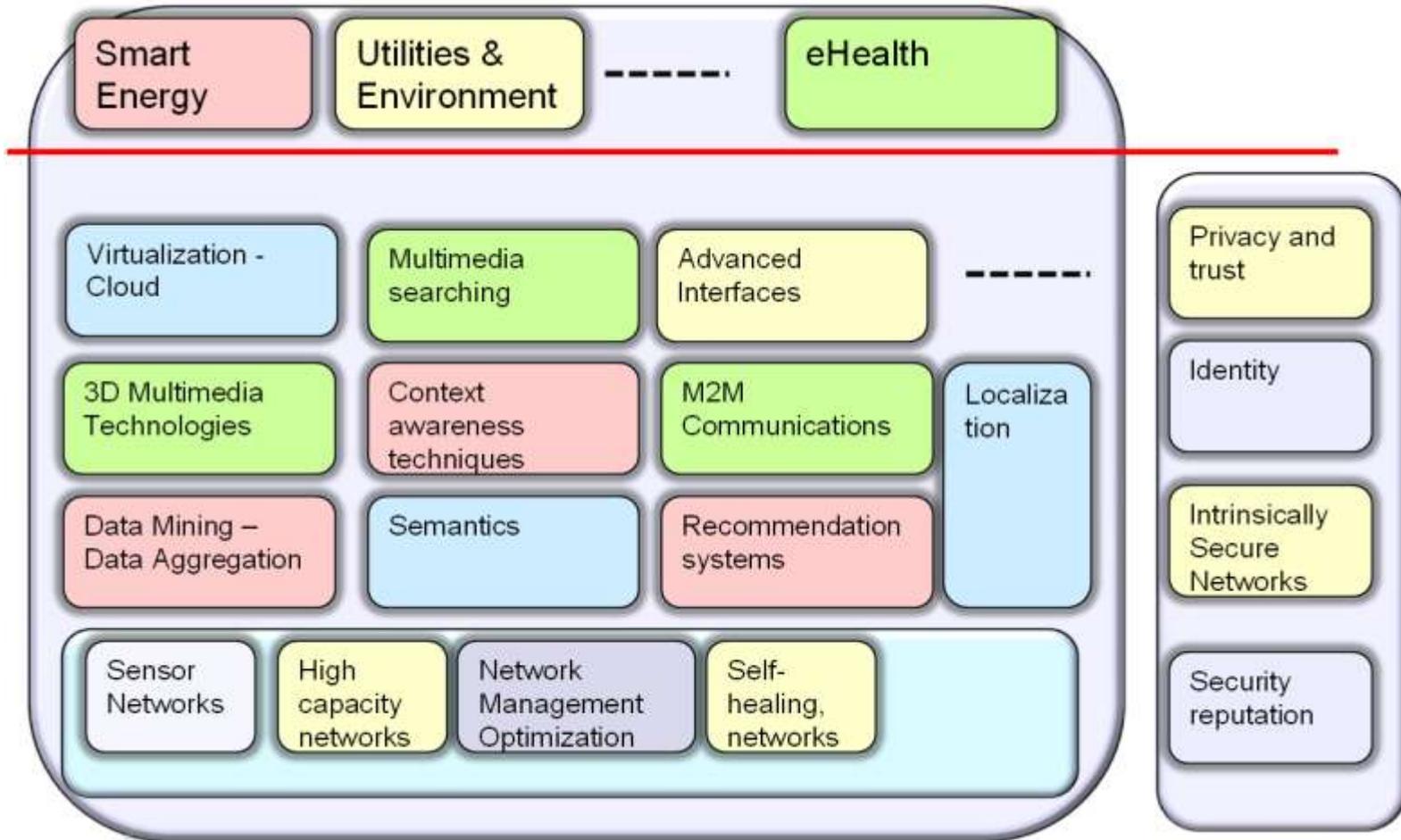
- **Comprehensive architecture approach**
- **Broad range of basic services for communication, payment, ordering, tracing, information provision, assistance and help**
- **Identification and coding schemes**
- **Security and privacy management systems**
- **Interfaces Systems and 3D technologies**
- **Governance principles and systems**
- **Awareness raising and training for operators and end-users**
- **Consideration of Legal aspects**

Future Internet-enabled services in “Smart Cities”, Gérald Santucci, EC, Jan 2010



EFII

PPP - Core Platform Architectural Approach



Source: *White paper of the Future Internet PPP definition*, Jan. 2010

http://initiative.future-internet.eu/fileadmin/initiative_documents/Publications/White_Paper/EFII_White_Paper_2010_Public.pdf

EFII – FI-PPP Core Platform Approach

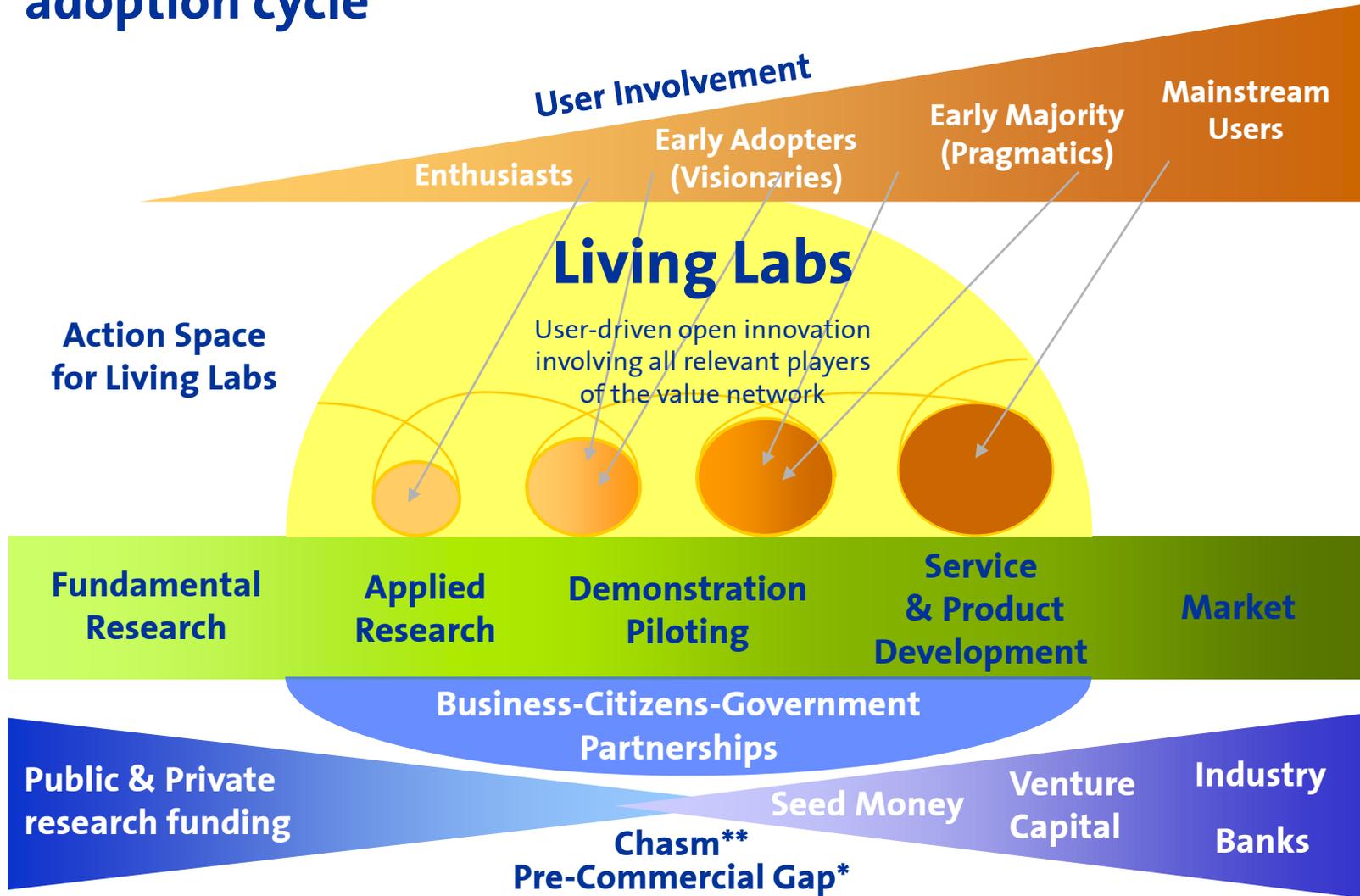
Initial set of common enablers

- Event / Data aggregation, transformation, correlation and Filtering
- Data / Data classification
- Entities Naming Resolution (applicable to services, things, devices, nodes, resources, ...)
- Service Repository
- Service composition, brokering and execution
- Application Communication Infrastructure
- Content/Service indexing, searching and discovery
- Localization
- Context Management
- Recommendation System / Decision Support
- Identity and Access Management
- Confidentiality and data sharing
- User privacy management
- Dynamic adaptability of services / content
- Device Description Repository
- Frontend Channel Maker (frontend access to content and applications)
- Generic rating, charging, billing
- Applications/Service marketplace
- Provision of shared Infrastructure (communication, computing, storage) as a Service
- Provision of Platform as a Service
- Large-scale media and data delivery
- Cloud federation
- Lifecycle Management Support
- Usage accounting
- Real-time logging
- Support for Analytics
- Tele-traffic analysis/servers
- DRM support
- One-to-many communication support
- Nomadic and mobility Support
- Permanent and Non-permanent Connectivity Support
- Dynamic Multi-homing Support
- Dynamic TCP stack and parameter tuning
- Network protection

Source: *White paper of the Future Internet PPP definition*, Jan. 2010



User-driven innovation within the technology adoption cycle



* MacDonald and Associates, 2004

** Geoffrey A Moore: Crossing the Chasm, 1999



The Living Labs Model

- **As a user-driven open innovation system, Living Labs speeds up the innovation process by addressing the user's needs:**
 - Citizens - Ever wanted to influence future technologies?
 - Companies and SMEs - Ever wanted to access larger or more varied markets?
 - Researchers - Ever dreamt of bringing revolutionary technological breakthroughs closer to the 'man on the street'?
- **The model benefits citizens, industry and research**
 - Living Labs **empower citizens**, as end-users, to influence the development of innovative services & products that eventually could benefit the whole society.
 - Living Labs allow **industry to develop**, validate and integrate new ideas, to partner with other companies and to increase their chances of success during product and/or service launches.
 - Living Labs facilitate the integration of technological innovation in society and increase return on investments in ICT **research**.

http://ec.europa.eu/information_society/activities/livinglabs/index_en.htm



ENoLL

Living Labs' main activities

- **Co-Creation:** co-design by users and producers
- **Exploration:** discovering emerging usages, behaviors and market opportunities
- **Experimentation:** implementing live scenarios within communities of users
- **Evaluation:** assessment of concepts, products and services according to socio-ergonomic, socio-cognitive and socio-economic criteria

Let's make the future of the Internet work for citizens, consumers and workers



The Public Voice

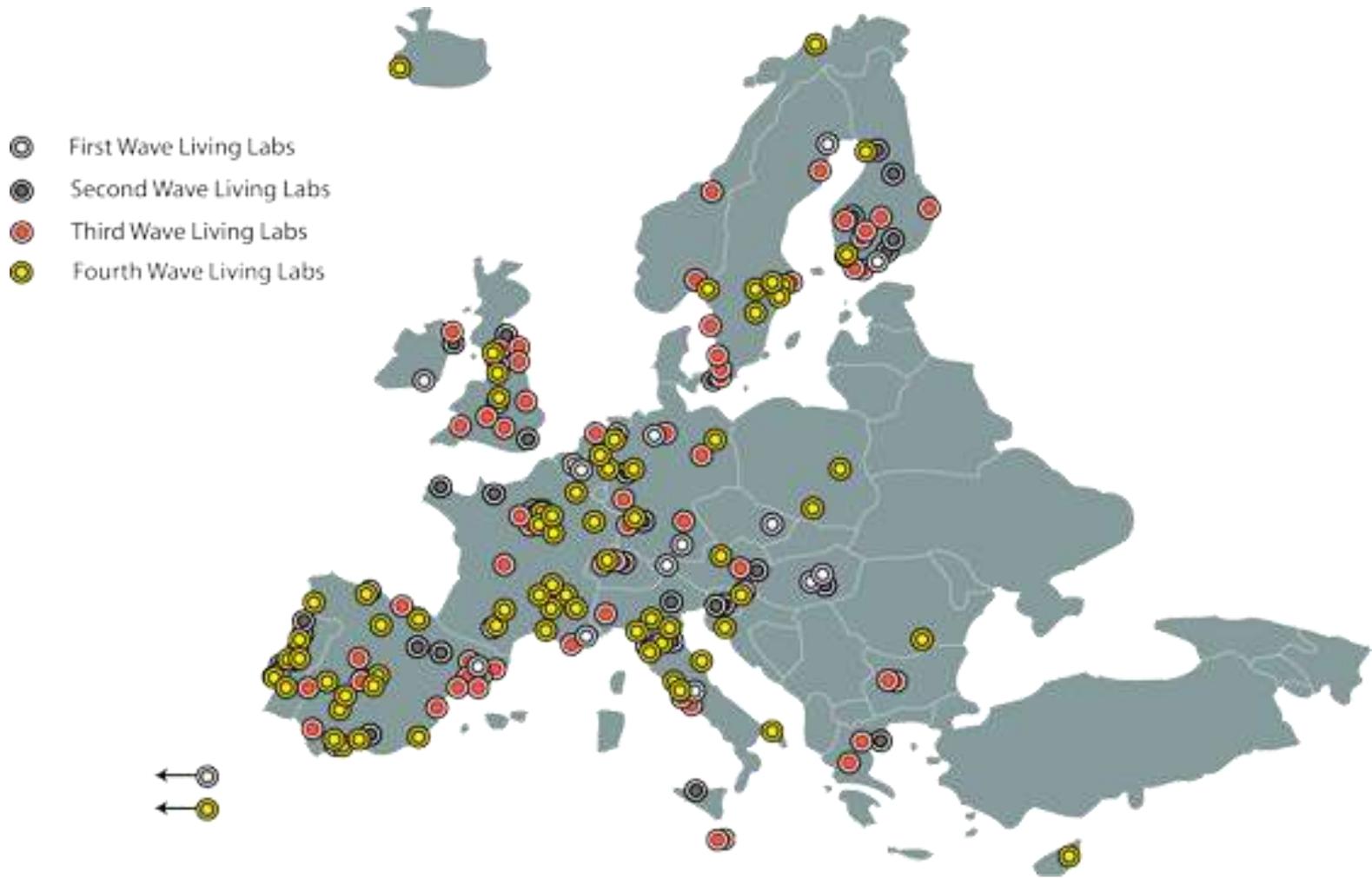
COEX Seoul June 16, 2008
thepublicvoice.org/events/seoul08



Paquete

<http://www.openlivinglabs.eu>

Experiences within ENoLL are addressing the widest application scope...



Source: <http://www.openlivinglabs.eu/>

But most Living Labs experiences are rarely addressing commercial services

- Smart City implementation will require coordination across 4 main axis: funding, user-driven approach, governance and interoperability of solutions
- Smart Cities are mainly promoted by Public Institutions (European Commission, City Councils, etc.), but private companies have started to gain positions (specially IT players such as IBM, Microsoft, SAP, etc.)
- Business models for Smart Cities are still unclear and require shaping multiparty stakeholder-system and cooperative business approach



A holistic approach to Smart Cities is required, shaping a multiparty stakeholder-system

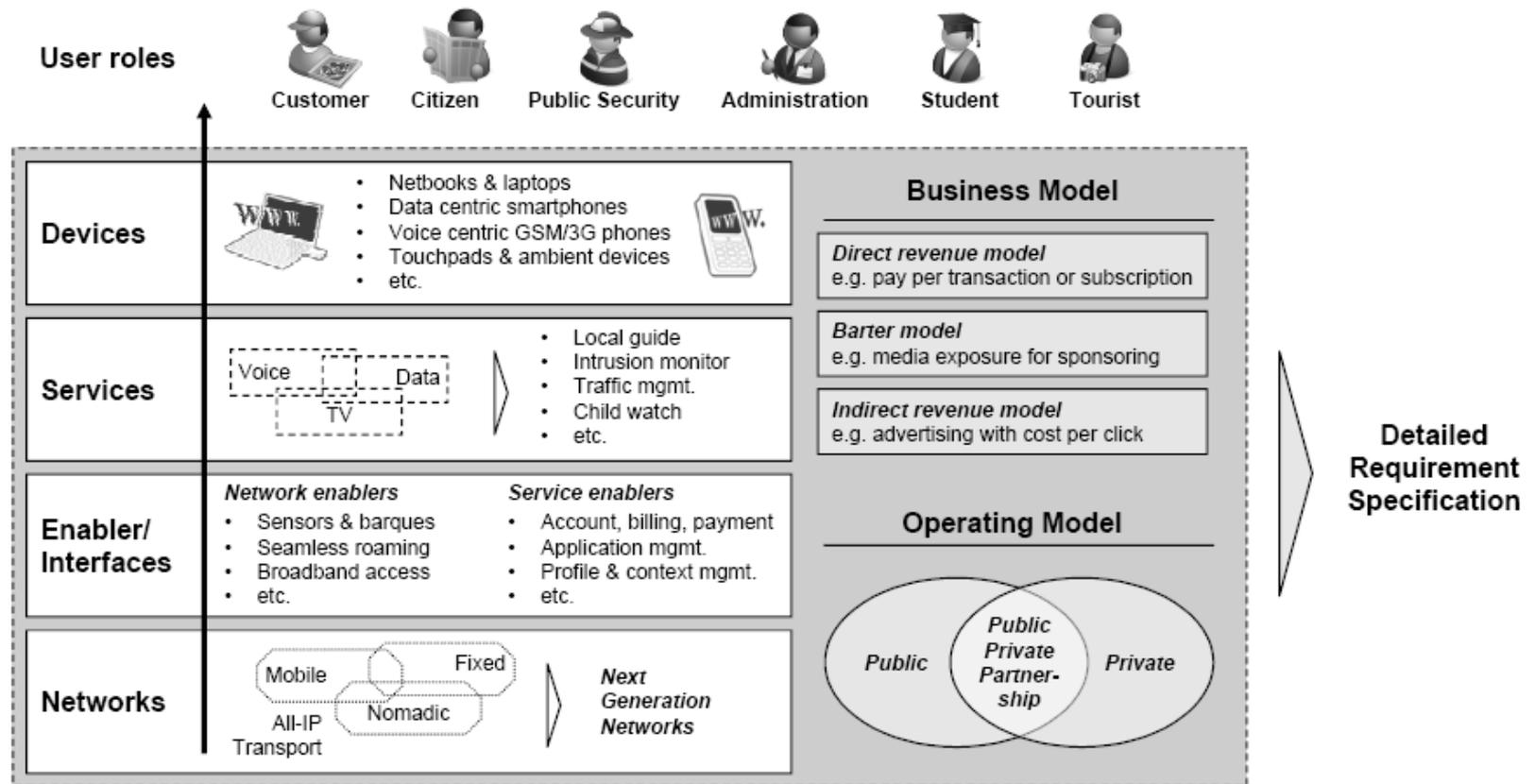


There are many ICT companies implementing solutions for Smart Cities ...



... but business models are still unclear and requires shaping cooperative business frameworks

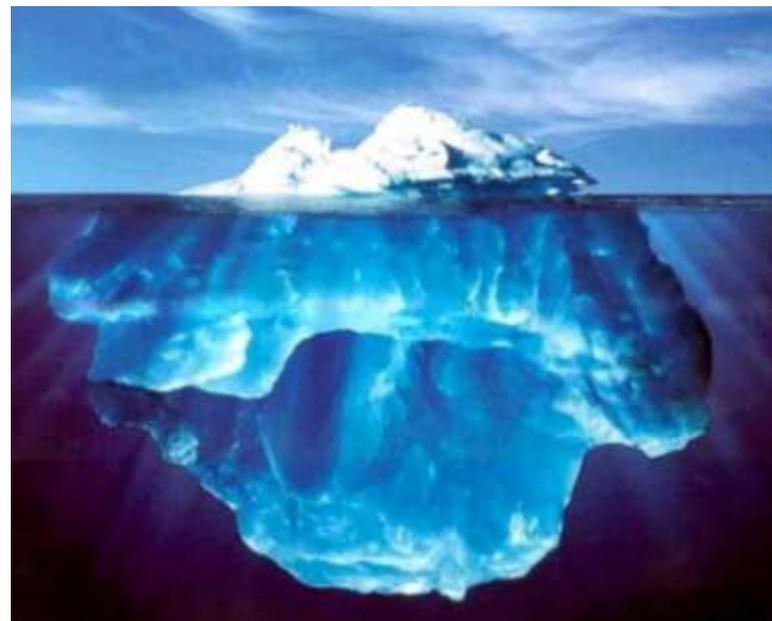
Business models for Smart Cities are still unclear and requires shaping multiparty stakeholder-system and cooperative business approach



The good news are that first business analysis conclude that several sectors/industries will benefit from more digitalized and intelligent cities

Examples for a city* of 1 million people

Smart metering	600.000 meters	\$120 million opportunity
Electric vehicle charging infrastructure	45.000 electric vehicles	\$225 million opportunity
Remote patient monitoring (diabetes)	70.000 people w/ diabetes	\$14 million opportunity
Smart retail establishments	4.000 stores	\$200 million opportunity
Smart bank branches	3.200 PTMs	\$160 million opportunity



Total Worldwide ICT Opportunity ≈ \$200 Billion

* Source: High level estimates given by IDC Report Boston March 4, 2010

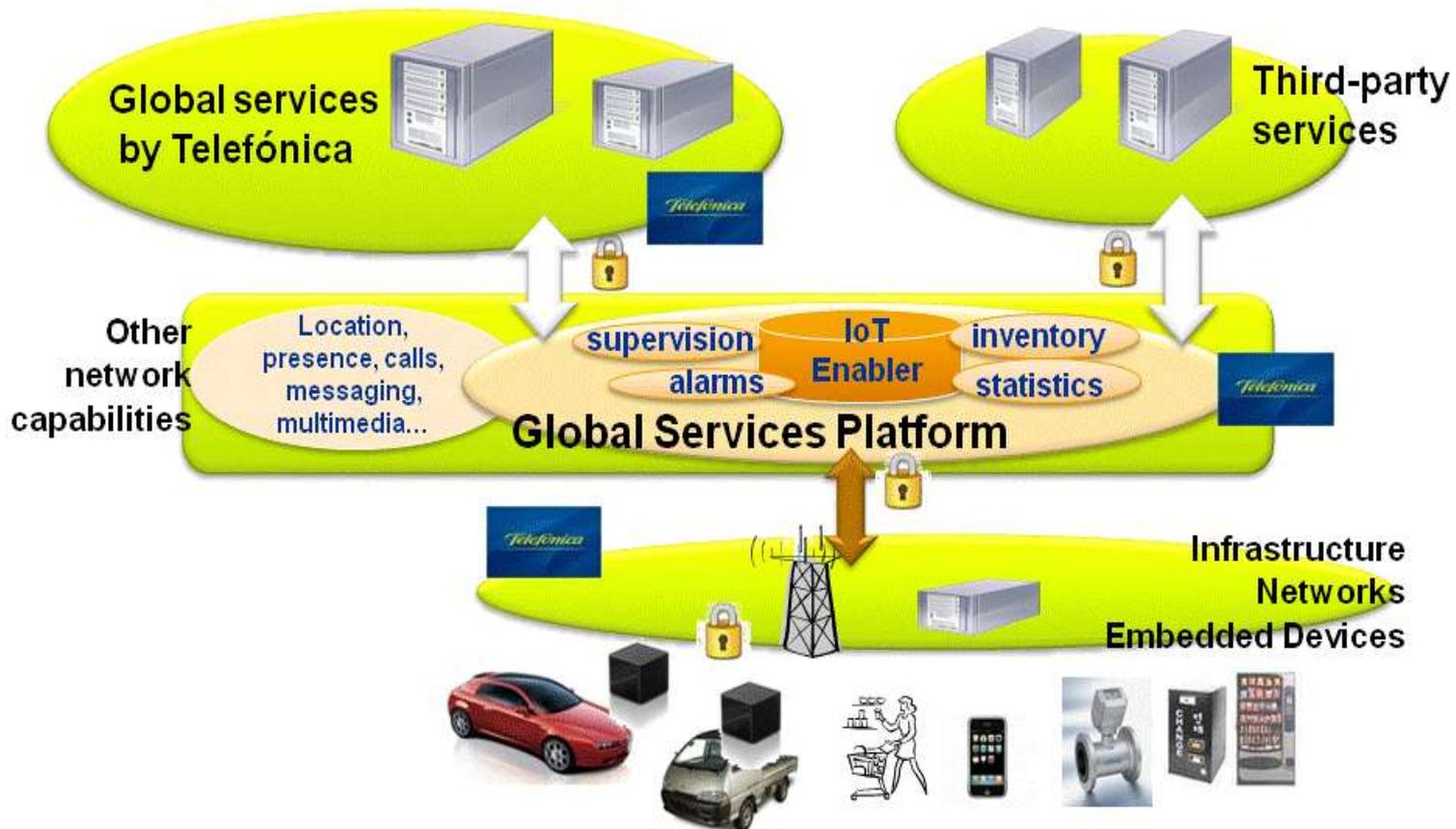


4 Smart Cities Technology Foundations

ICT technologies can make the IoT paradigm a reality, providing the functionalities required to build up Smart Cities

The Telco model for the IoT

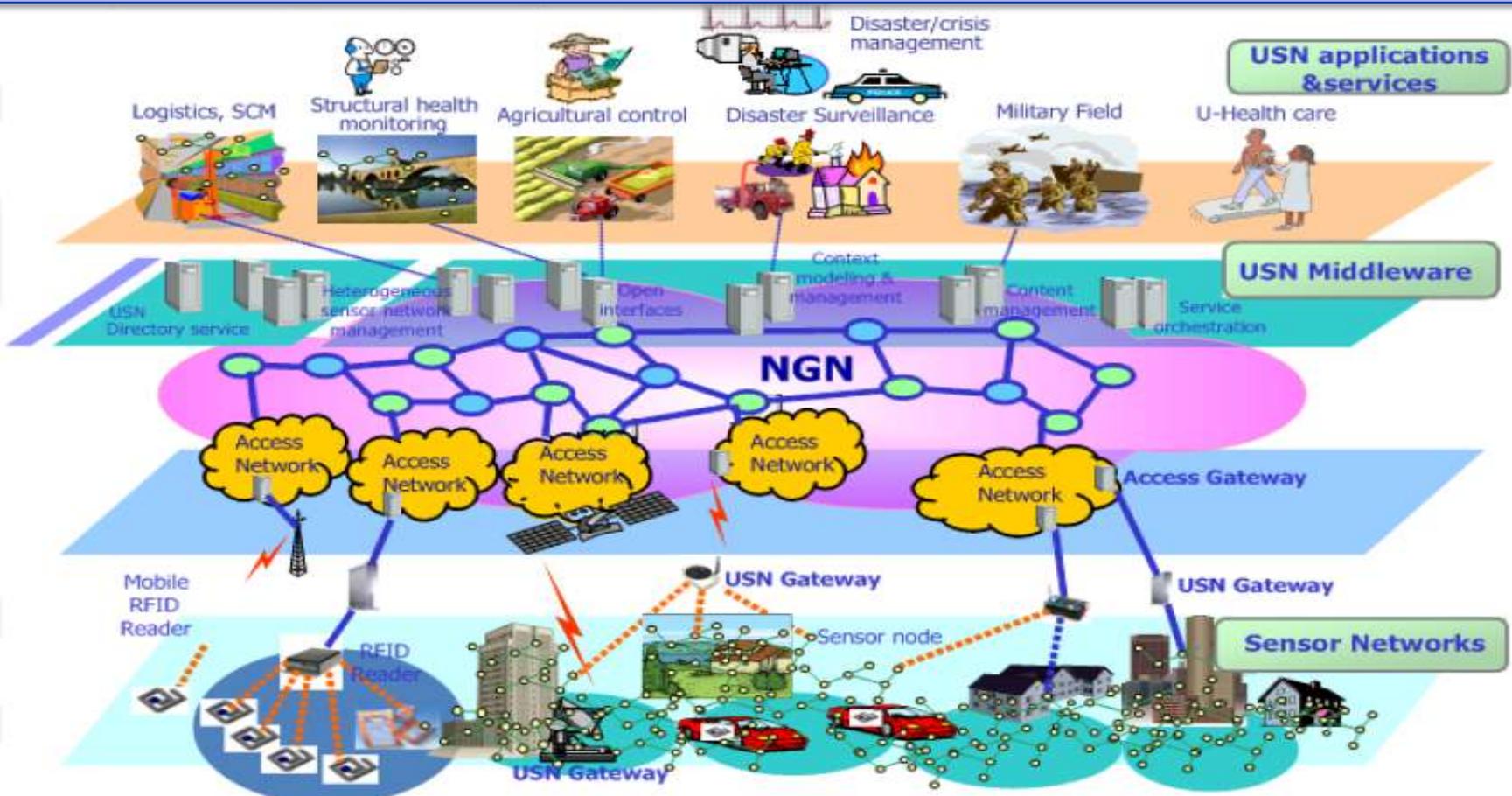
Global infrastructure for communicating people, machines, and objects providing services to citizens and other companies by interconnecting every single object to the network (IoT: Internet-of-Things)



Telefónica reference implementation

ITU-T Ubiquitous Sensor Network (USN)

« A conceptual network built over existing physical networks which make use of sensed data and provide knowledge services to anyone, anywhere and at anytime, and where information is generated by using context awareness. »



USN Platform – Key capabilities

- **Unified information modeling:** The information should be provided to the services using a unified information model, regardless the particular information model used by the sensor technologies.
- **Unified communication protocol:** Services should be agnostic to the communication protocol used. The platform should provide access to the information regardless the particular underlying communication protocol used (ZigBee, 6LowPan, ISA-100.11.a, etc.).
- **Horizontally layered approach:** The platform should be build following a layered approach, so services and networks are decoupled in order to evolve independently

- **Based/Extended on Standards**



- **3GPP IP Multimedia Subsystem (IMS)**



- **Service Enablers : Open Mobile Alliance (OMA) Service Environment (OSE)**

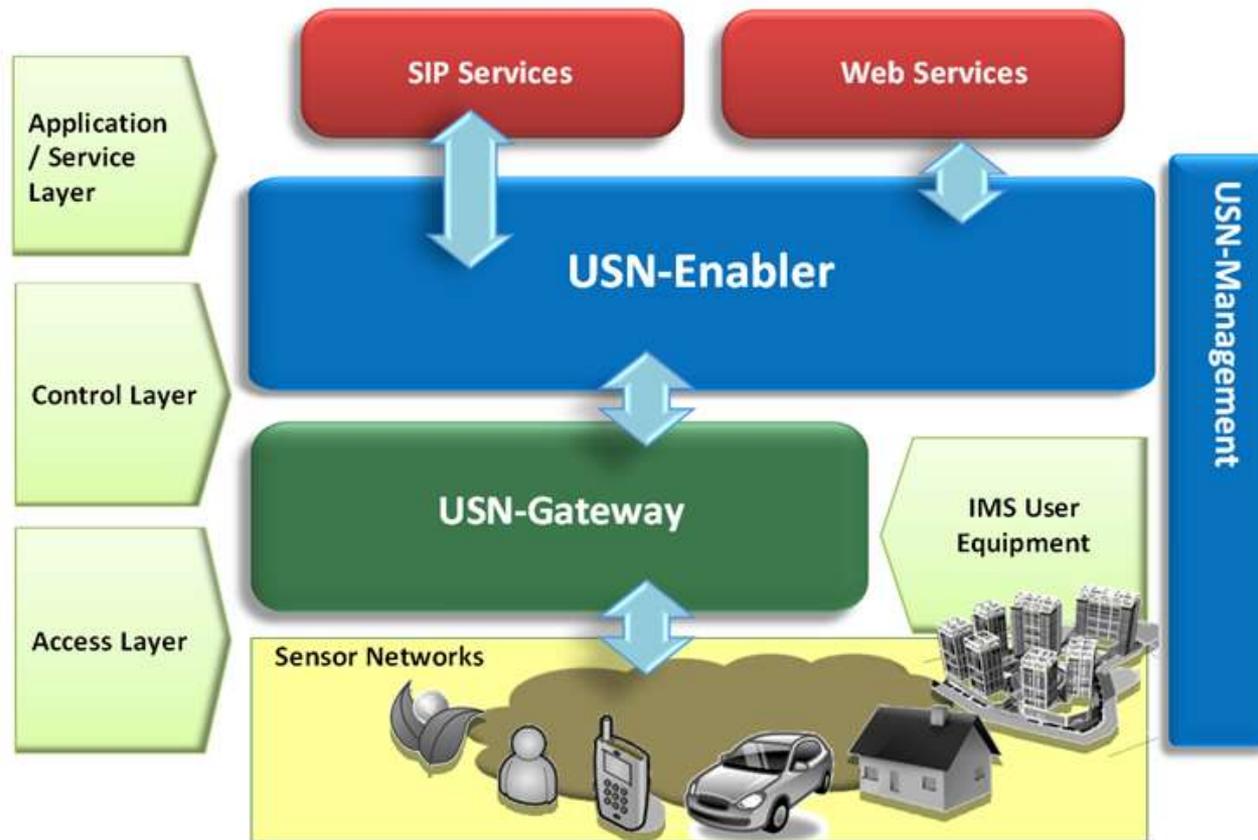


- **Sensor Web Enablement family of standards from Open Geospatial Consortium (OGC®): SensorML, O&M, SOS, ...**

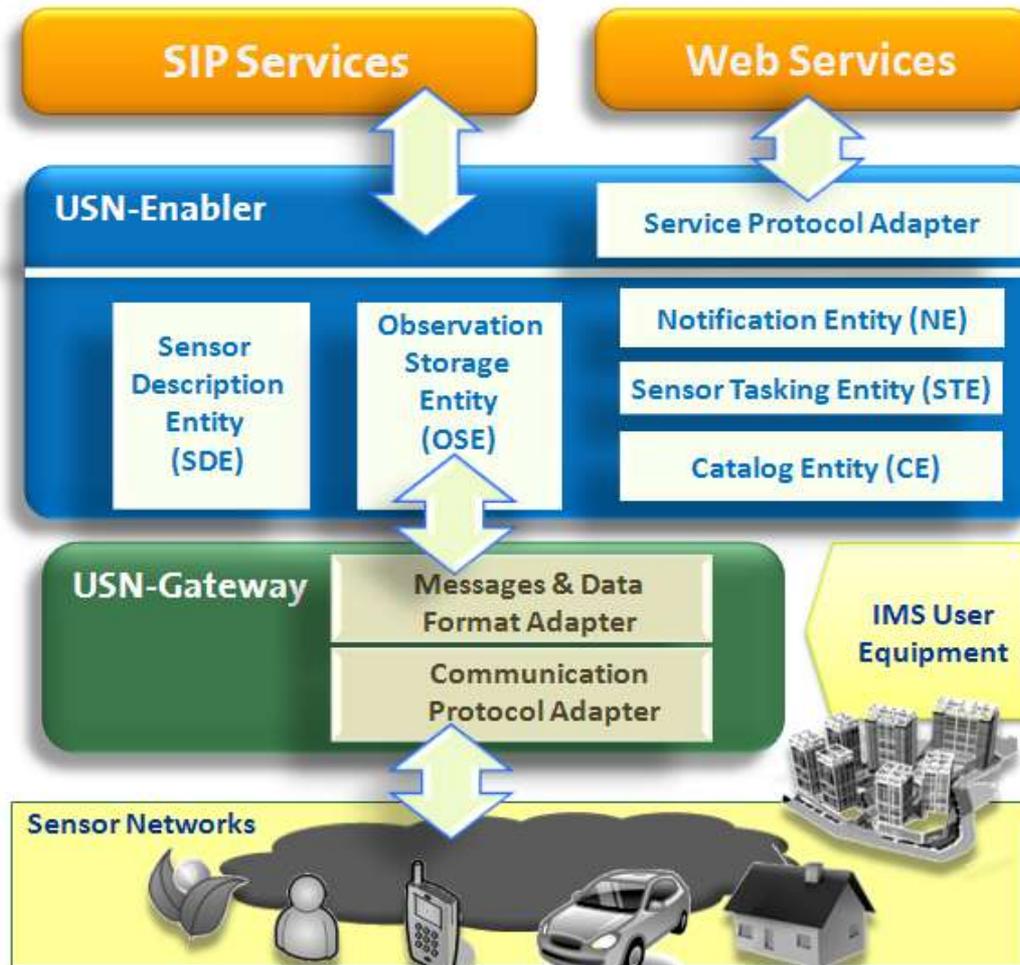


USN Platform – Reference Architecture

Integration of heterogeneous and geographically dispersed machine / sensor / actuator networks into a common infrastructure where services can be developed in a cost efficient manner.



USN Platform – Functional blocks



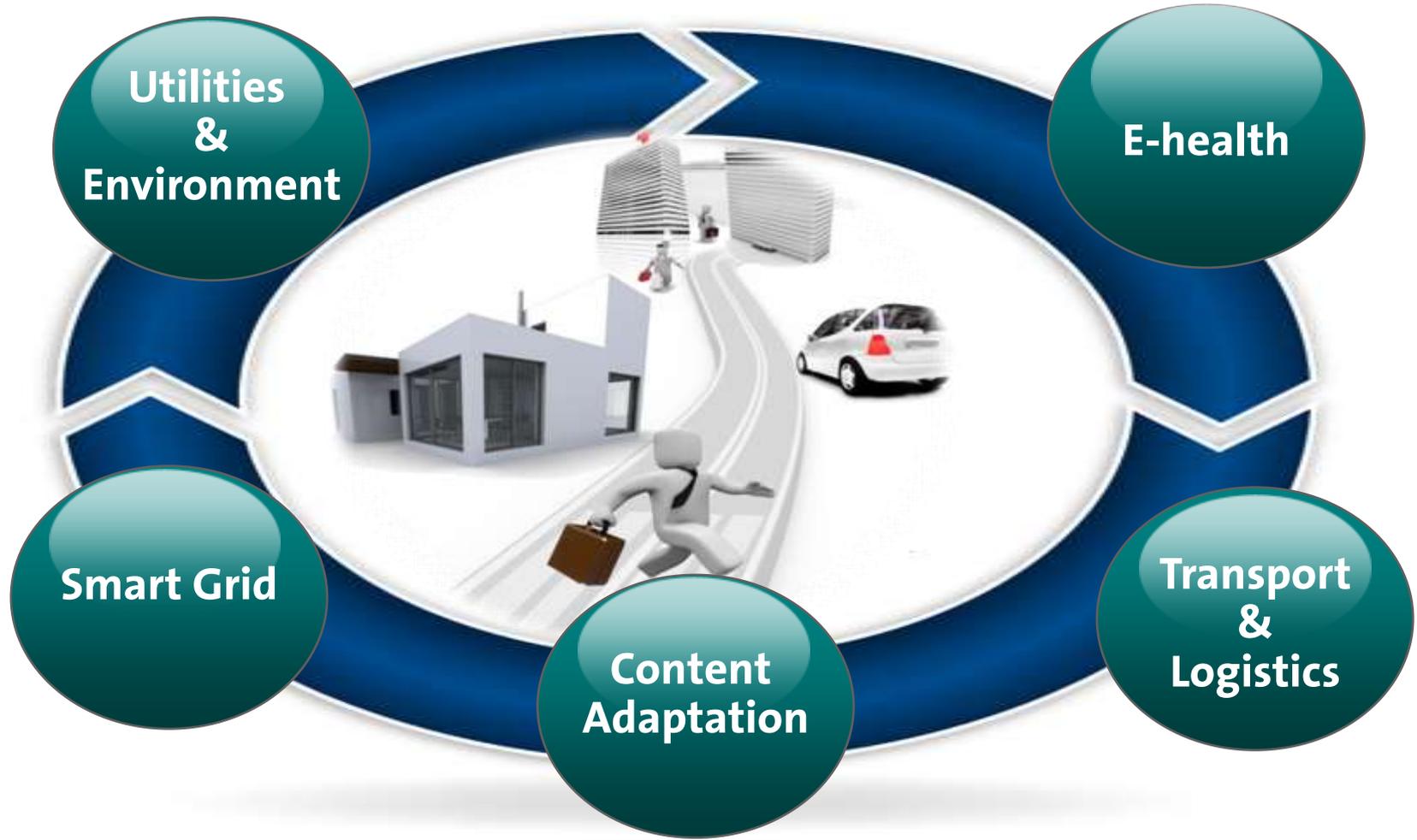
USN- Gateway:

- ⊙ Abstract and efficient communication management (Service-Oriented Communication)
- ⊙ Bridging machines / sensors / actuators to unified communication protocols (SIP)
- ⊙ Unified communication network management, xDSL, GSM, GPRS, UMTS, WiFi, ...
- ⊙ Defined as IMS User Equipment

USN- Enabler:

- ⊙ Resource Discovery: look-up registered machines/sensors
- ⊙ Observation Storage: information repository
- ⊙ Publish-Subscribe-Notify: simple & complex conditions and events.
- ⊙ Homogeneous Remote Execution capabilities

USN Platform – Application scenarios



USN Platform – Summary

Added Value – Advantages

- **Generic architecture based on a flexible and modular design.**
- **Not limited to the current sensing or networking technologies**
- **Adaptable for present and future Service Architectures**
- **A Standard procedures integrated in the current and future Networks**
- **Open to third party players**

Key issues

- **Network functionalities: integrated access to a wide range of network technologies**
- **Homogeneous representation of sensor, actuator and machine – related data and information**
- **Service Oriented deployment environment**



5 Research Infrastructures



SmartSantander

Call FP7-ICT-2009-5

Proposal Number: 257992

Federation mechanisms can provide the model for interconnecting multiple testbeds



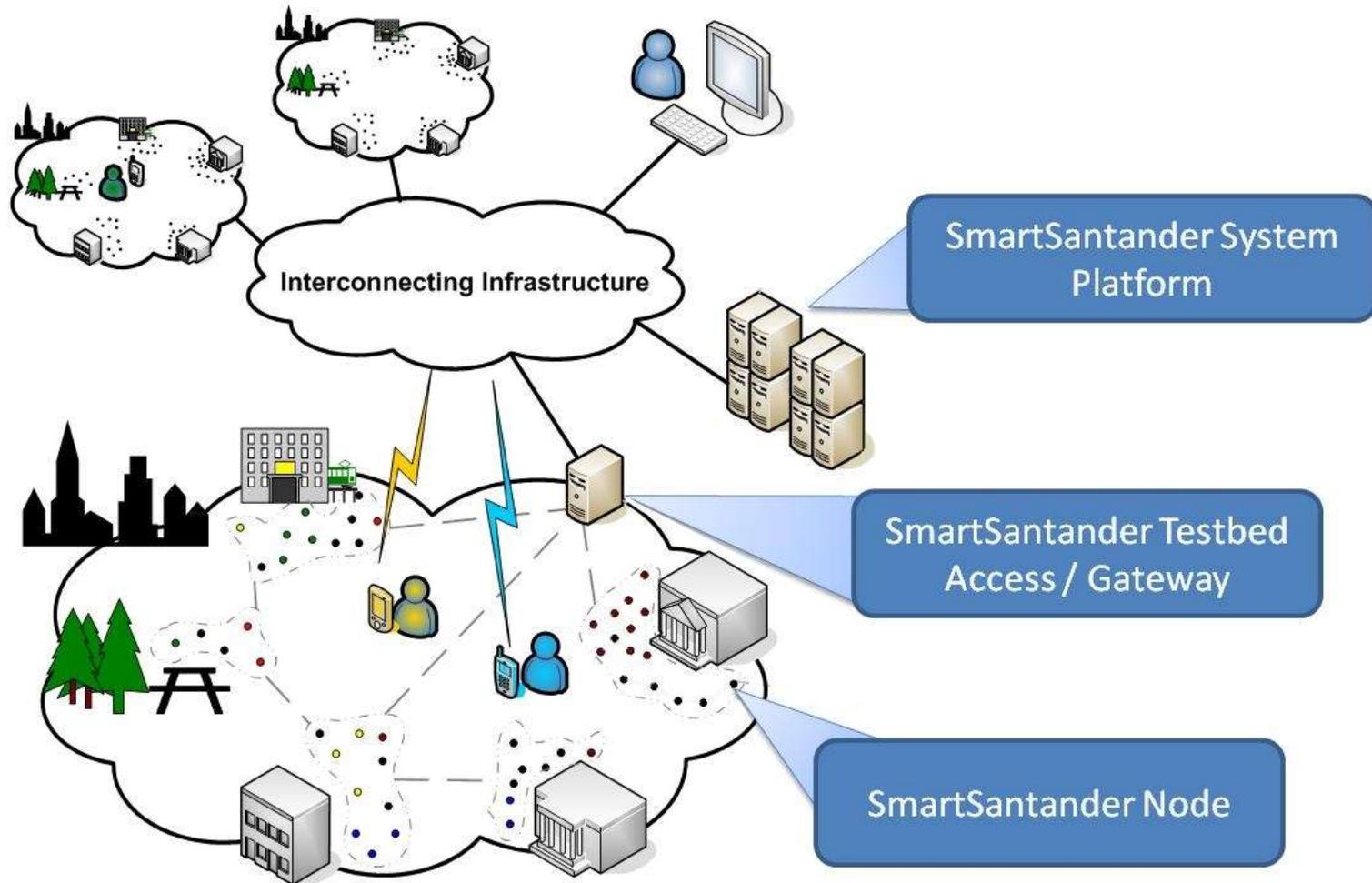
Smart Santander aims at providing a European experimental test facility for the research and experimentation of architectures, key enabling technologies, services and applications for the Internet of Things (IoT) in the context of the smart city.



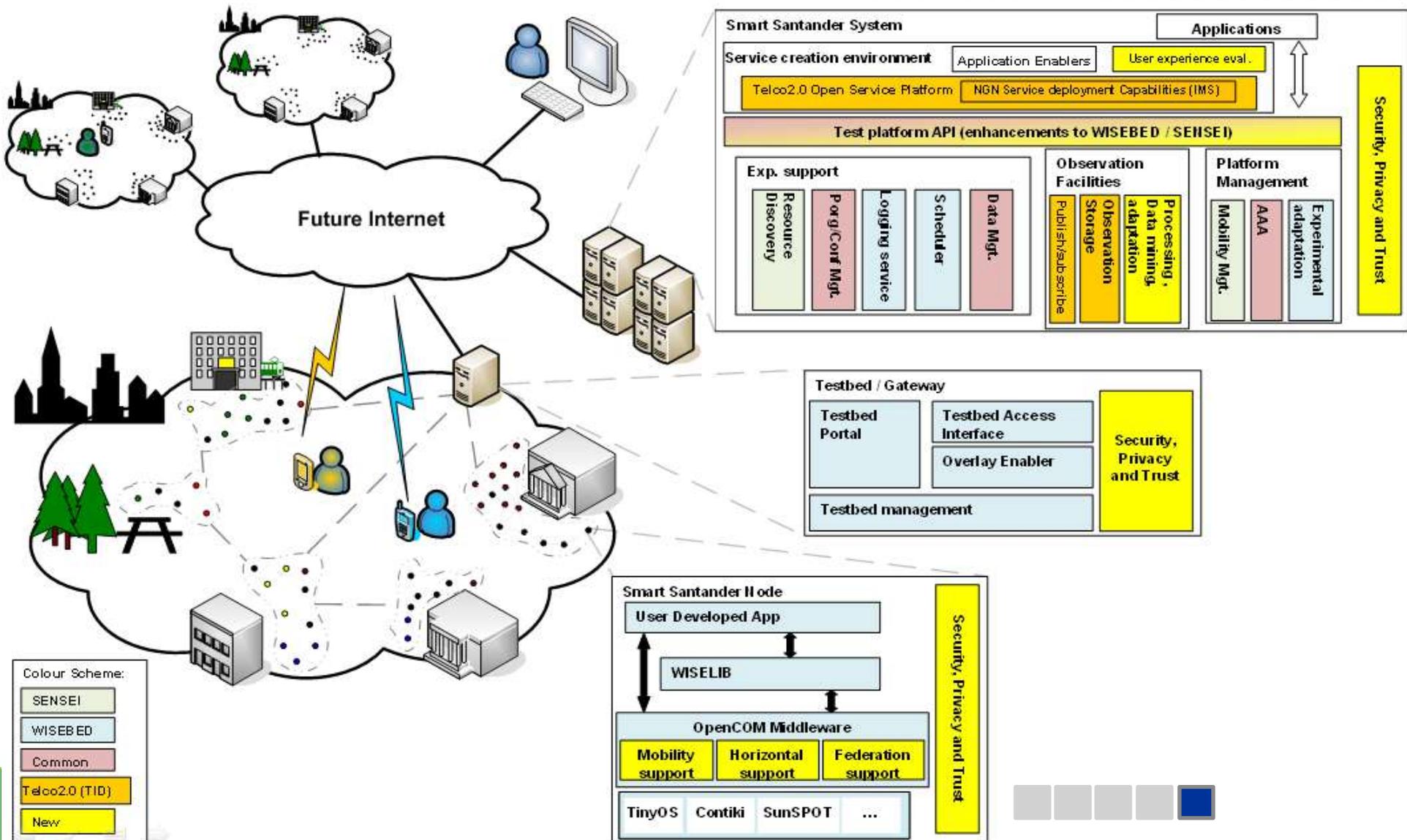
SmartSantander will validate an open federation model, conceived to be easily replicated, and based on the FIRE approach



SmartSantander IoT architecture building blocks



SmartSantander integrates the outcomes of its predecessor projects SENSEI and WISEBED to create a groundbreaking IoT architecture



The testbed will involve a wide hardware infrastructure & sensor type diversity



- The type of sensors and mobile devices to be used is very much related to the different use cases that the project is planning to implement, some of them being related to:

- Public buildings, installations monitoring and management
- Parks and gardens control and management
- Public Transportation and traffic control
- Environmental management and monitoring



- Wide range of sensors and mobile devices is considered

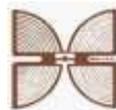


ZigBee /
3G, WiFi,
Ethernet
gateways



ZigBee
RF modules

Micro-controllers



RFID
tracking

Environmental:
Temperature, humidity
pressure, ambient light,
CO₂, wind speed ...



Personal care
and assistance



GPS, presence,
smoke & gas detectors,
IP video cameras



Research driven and open to experimentation... ... but other user profiles are also considered



■ Typical user profile

- Researchers (Future Internet/IoT)
- End users (social impact)
- Service providers

■ Types of experiments

- Building blocks for IoT architecture and validation
- Impact of IoT on Networks and service layer integration
- Privacy and trust evaluation and user acceptance
- Information aggregation and mining

■ Policies and conditions

- Third party experimentation bounded by contracts, e.g. based on PanLab model
- Open calls for FIRE members based on EC guidelines

■ Use cases

- A tentative list of concrete use cases has been suggested within the proposal
- The first use case will be implemented based on an evaluation of users needs and is not pre-concluded
- The project uses User Driven Innovation methodologies to design use cases



SmartSantander is based on a sustainable approach to maintain deployed infrastructure



- Sustainability and exploitation beyond project duration are closely bound
- A **Sustainable Exploitation Plan** will be produced by the project, that is in fact a business plan to guarantee the sustainability of the deployed infrastructure.
- As a support to this exploitation plan:
 - The **Regional Government** will allocate a budget in the initial time period after the ending of the project.
 - The **City Council of Santander** is committed to maintain the sensor network deployed since it will be very useful to enrich some of the city services.
 - **Banco de Santander** in close cooperation with Regional authorities and University of Cantabria will explore the possibilities for setting up an **ICT Institute**, with private and public sponsorships.
 - **Telefónica, University of Cantabria, the Regional Government** and the **City Council** have committed to submit **new cooperative proposals** to national funding provided by the Spanish Government to singular infrastructures.
- At the **other EU locations** equivalent actions based on the same model !



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