Internet of Things:
A main driver for a true Green IT?

Jesus Bernat Vercher
Telefónica I+D

6-8 September 2010

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ICT: Environment and Climate Change

Green IT Definition

- Green computing:

"The study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems—such as monitors, printers, storage devices, and networking and communications systems—efficiently and effectively with minimal or no impact on the environment."

San Murugesan,
"Harnessing Green IT: Principles and Practices"
IEEE IT Professional,
January-February 2008, pp 24-33.

ICT: Environment & Climate Change

Green IT initiatives

GreenTouch™

the green grid®
get connected to efficient IT

climate savers computing℠

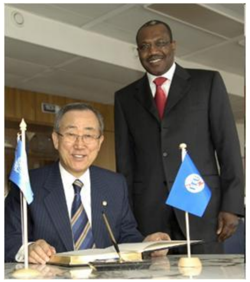
ICT: Environment & Climate Change

Impact

"ITU is one of the very important stakeholders in the area of climate change"

Ban Ki-moon

UN Secretary-General



ITU and Climate Change

ITU SG5 "Environment & Climate Change" (May 2009)

- The impact of ICTs on Climate Change:
  - **Direct impact**: the reduction of ICT's own emissions over their entire lifecycle
  - **Indirect impact**: The mitigation that follows through the adoption of ICTs in other relevant sectors
  - **Evaluation impact**: facilitating the monitoring of relevant climate parameters.

1) Greening of ICT system itself (Green of ICT)

2) Greening of other fields through extensive use of ICT (Green by ICT)

3) International contribution (e.g., establishing techniques for evaluating effectiveness in reducing CO_2 emissions)

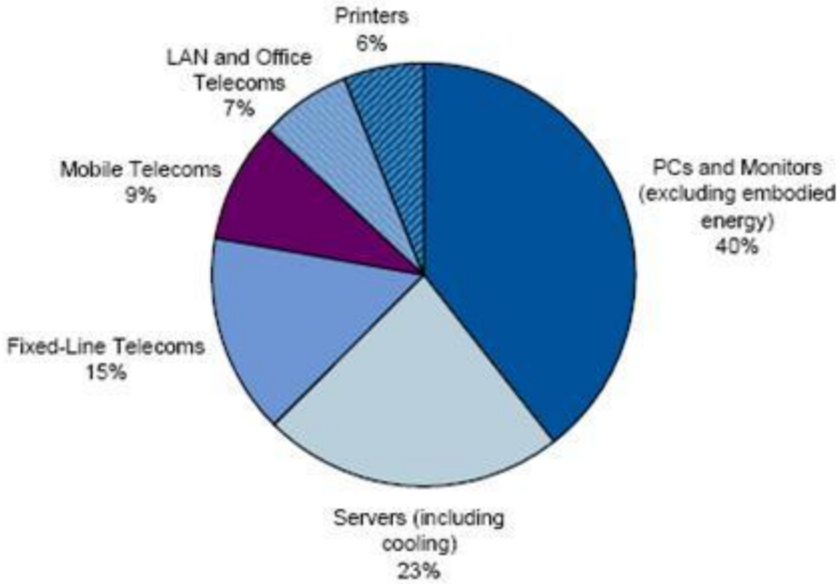
Reduction of CO2 emissions

Koichi Fujinuma
Ministry of Internal Affairs and Communications
ICT & Climate Change Policies and Actions in Japan
ITU-T WORKSHOP "ICTs: Building the Green City of the Future"
Shanghai, China, 14 May 2010

ICT: Environment & Climate Change

Direct Impact (I)

- ICT industry is responsible for a relatively small portion of global greenhouse gas emissions – about 2-to-3 % (ITU source)



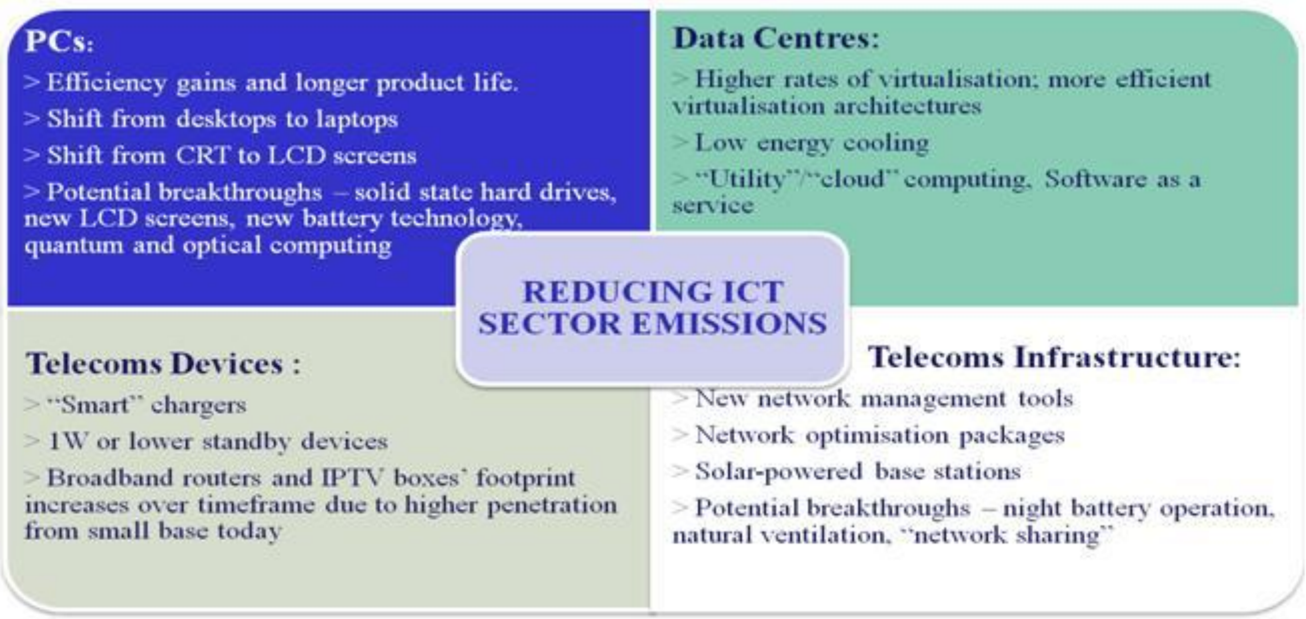
- Telecoms contributed around one quarter of this total
- Airplanes and shipping about 3% each

- In spite of increasing ICT network usage the current industry efforts to reduce power consumption should enable the ICT sector to maintain its current greenhouse gas profile over the next decade.

ICT: Environment & Climate Change

Direct Impact (II)

- ICT companies are taking steps both to reduce their own energy consumption which are currently running at 10-to-20% annually.



- **GreenTouch**: Significantly Reducing the carbon footprint of ICT devices, platforms and networks by fundamentally transforming communications and data networks, including the Internet

GreenTouch™

http://www.greentouch.org/

ICT: Environment & Climate Change

Indirect Impact (I)

Intergovernmental Panel on Climate Change (IPCC) calls for a 50-85% reduction in CO2 emissions by 2050 to mitigate risks of climate change

The Bad News: **IT accounts for 2% of global CO_2 emissions**

The Good News: **IT can significantly contribute to control and reduce the 98% of CO_2 emissions caused by other activities and industries**

"… you can't make a product greener, whether it's a car, a refrigerator or a traffic system, without making it smarter — smarter materials, smarter software or smarter design." - Thomas L. Friedman

Sources: The IPCC Fourth Assessment Working Group Reports: Key Findings, Dr. R. K. Pachauri, Chairman, IPCC, Sept 2007; Gartner, Green IT, October 12, 2007; "The Green Road Less Traveled" by Thomas L. Friedman, The New York Times, July 15, 2007, http://select.nytimes.com/2007/07/15/opinion/15friedman.html?scp=2&sq=thomas%20l%20friedman%20july%202007%20greener%20smarter&st=cse

ICT: Environment & Climate Change

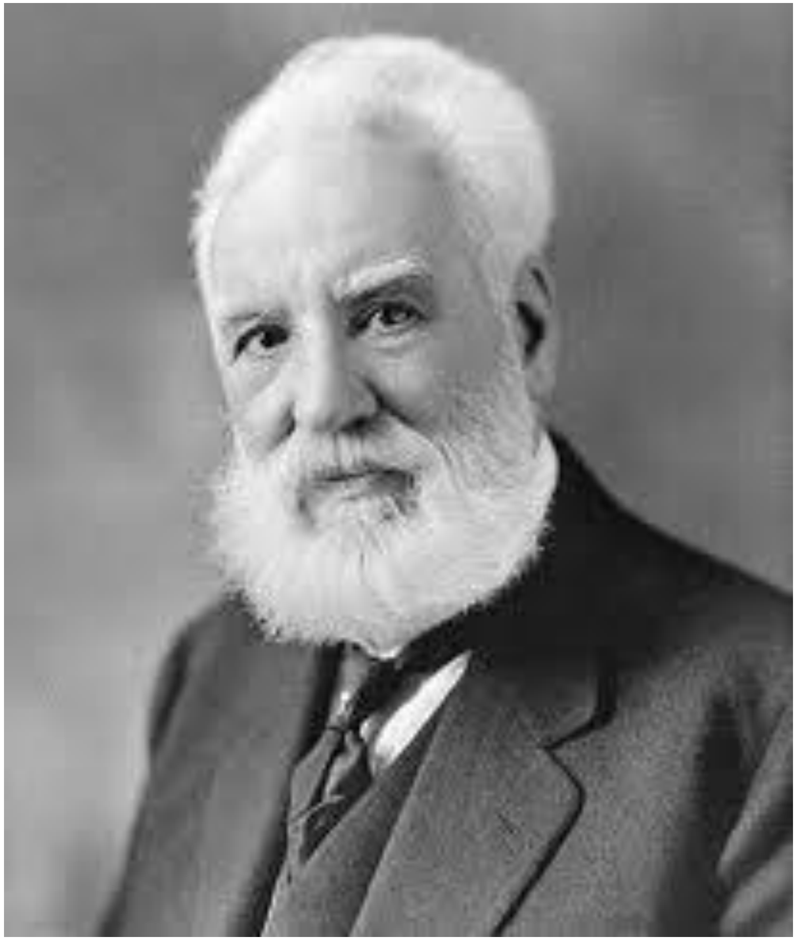
Indirect Impact (II)

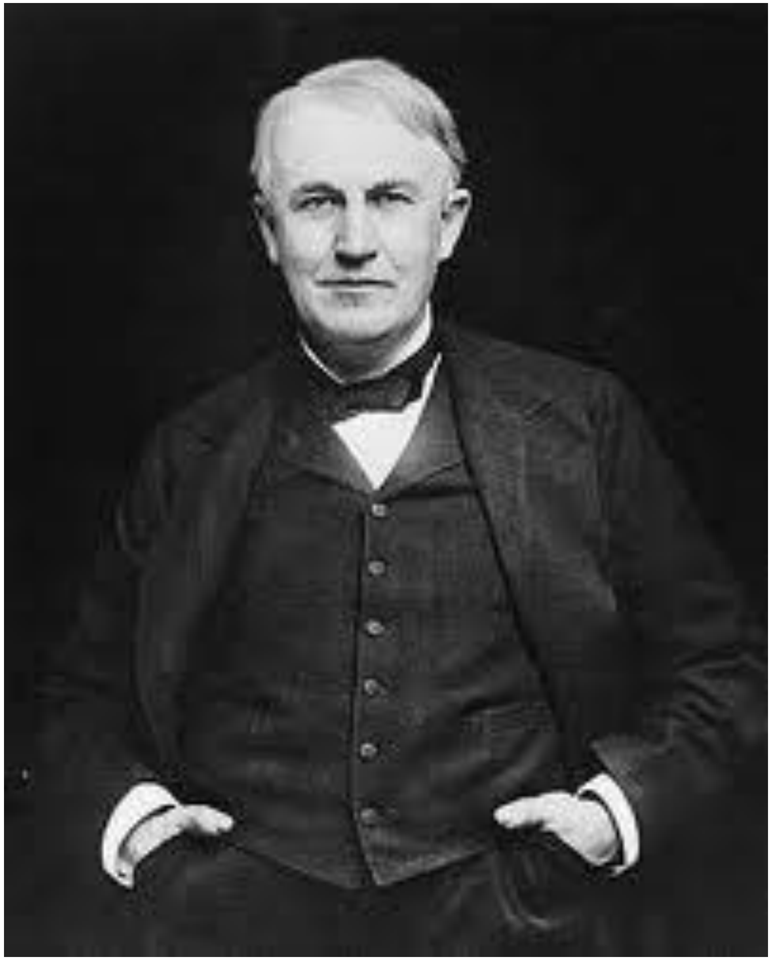
ICT constitutes "our collective nervous system," touching nearly every industry sector (World Economic Forum)

- **Smart electricity Grids and Smart Metering**: using ICT capabilities to more efficiently generate and distribute electricity, would impact billions of commercial and residential subscribers worldwide.
- **Transport**, the second-leading greenhouse gas emitting sector after energy:
  - ICT can eliminate the need for much travel through advanced video conferencing and web-based seminars.
  - ICT systems and solutions can help reduce transport CO_2 emissions through so-called intelligent transport systems, in applications such as traffic management and parking optimization.
- **Smart Building / Smart Cities:** technologies for more energy efficient building design, construction and operation: buildings represent another area where ICT advances can dramatically reduce CO_2 emissions.

http://www.greentouch.org/

ICT: Environment & Climate Change
Indirect Impact: an example





ICT: Environment & Climate Change

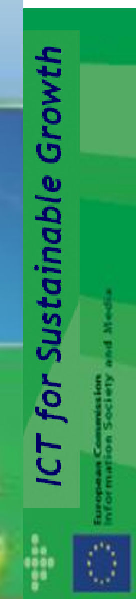
Evaluation Impact

Climate Change Monitoring:

- Conducting and managing studies on remote-sensing
- Providing key climate data via radio-based applications

Environmental Management & Protection:

- Systems for managing specific natural areas or ecosystems such as coasts,
- Managing the environmental enterprise in the public and/or private sectors

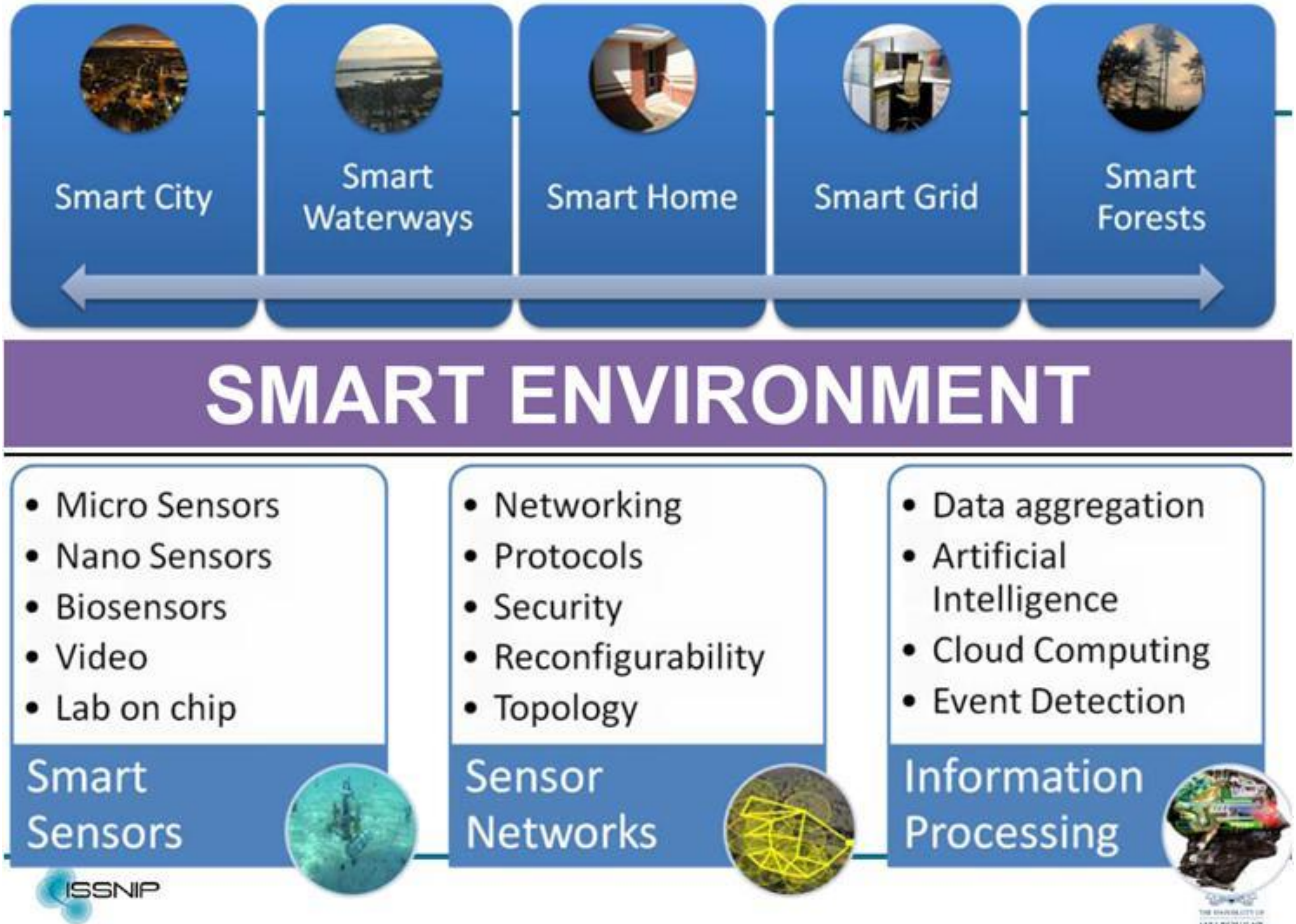


ITU
and climate change

"... ICTs are essential to our understanding of the environment and to our ability to deal with environmental change..."

ICT: Environment & Climate Change

Enabling Technologies



M. Palaniswami

Towards Sustainable Smart Cities - Role of Large Scale WSNs

ISSNIP - The University of Melbourne, Australia

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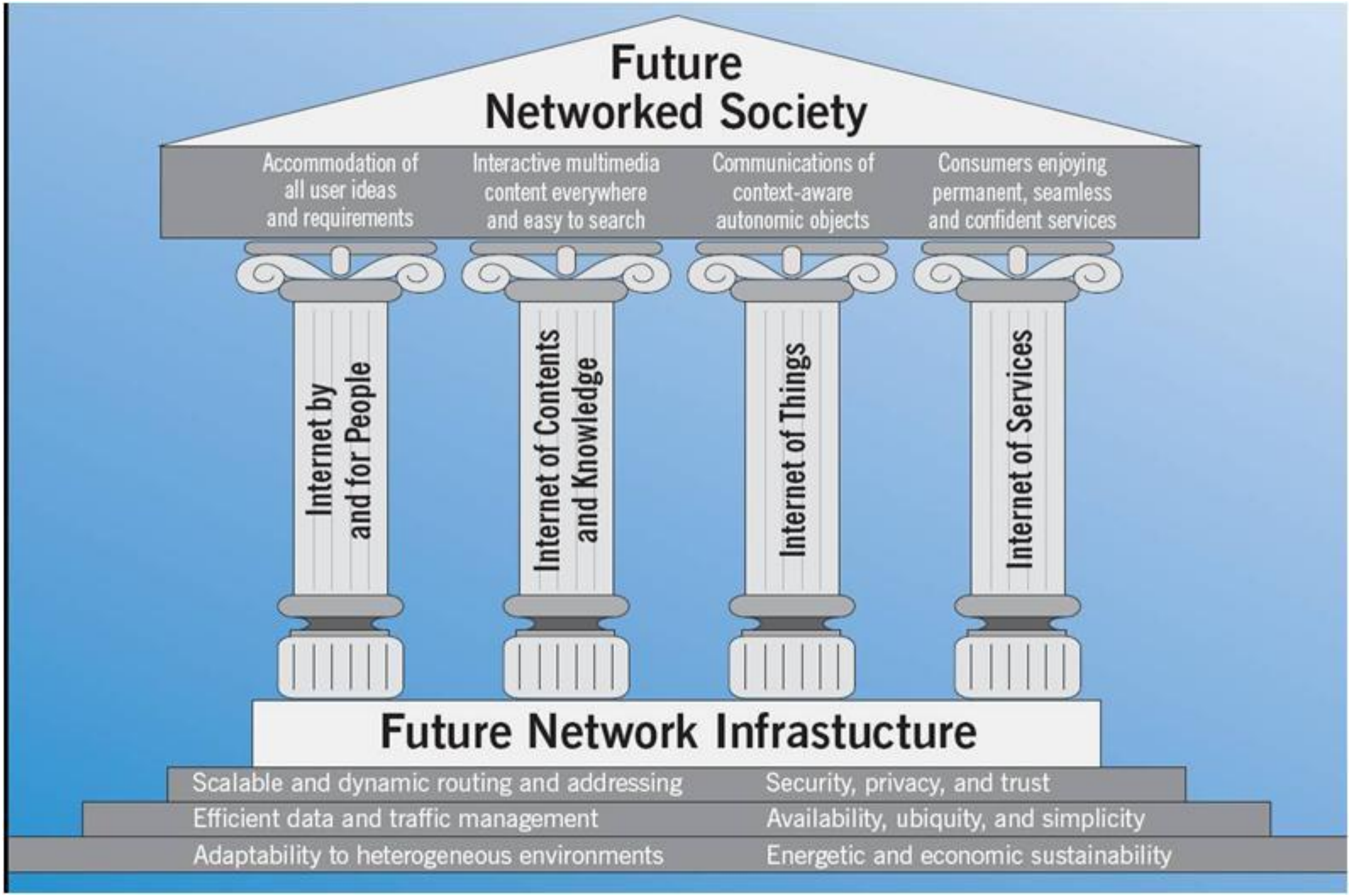
Internet of Things
Future Internet



Internet of Things

Concept

- The Internet of Things (IoT) envisions the integration of a myriad of smart interconnected objects embedding pervasive information processing and intelligent interfaces for advanced machine-to-machine, personal and social interaction.

The internet of Things
Björn Raunio 2010
.SE

"The Internet of Things has the potential to change the world, just as the Internet did. Maybe even more so."

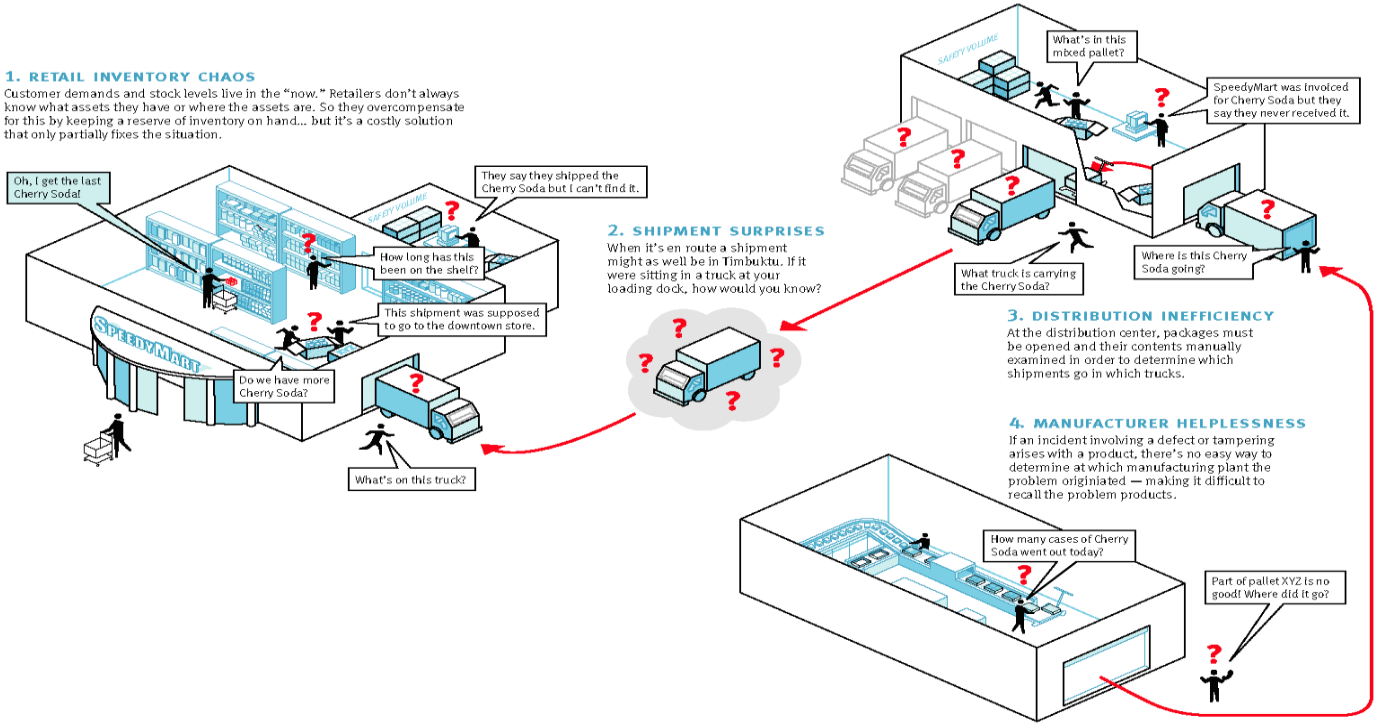
Kevin Ashton, 2009

Cofounder of the Auto-ID Center at the MIT

Internet of Things

History (I)

- The first reference to the term “Internet of Things” is dated in 1999 associated to Kevin Ashton and David L. Brock, founders of the Auto-ID Centre in the MIT
- The most relevant milestone of the Auto-ID Centre was the launch in 2003 of the EPC Network (Electronic Product Code)
  - An Open architecture for the identification and tagging of objects.



Internet of Things

History (II)

- The concept of the “Internet of Things” appeared in 2005 when the International Telecommunications Union (ITU) publish the report:

"The Internet of Things", ITU, November 2005.

Internet of Things will connect the world's objects in both a sensory and intelligent manner through combining technological developments in:

- *item identification ("tagging things")*
- *sensors and wireless sensor networks ("feeling things")*
- *embedded systems ("thinking things")*
- *nanotechnology ("shrinking things").*

The ITU also identified as main challenges for the IOT :

- *Standardization and Harmonization*
- *Privacy and Social and Ethical aspects.*

Internet of Things

Why?

Internet of Things — An action plan for Europe

Brussels, 18.6.2009 COM(2009) 278 final

IoT covers different modes of communication: things-to-person communication and thing-to-thing communications, including Machine-to-Machine (M2M) communication that potentially concerns 50-70 billion 'machines', of which only 1 % are connected today.

Report on "Disruptive Civil Technologies"
US National Intelligence Council (April 2008)

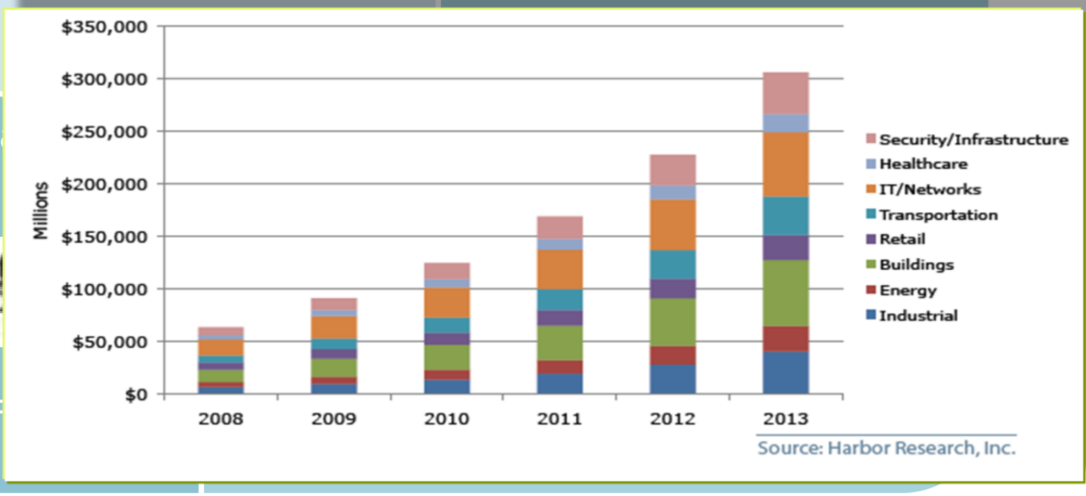
The Six Technologies with Potential Impacts on U.S. Interests out to 2025 are: Biogerontechnology; Energy Storage Materials; Biofuels and Bio-Based Chemicals; Clean Coal Technologies; Service Robotics; ***The Internet of Things****.*

IoT

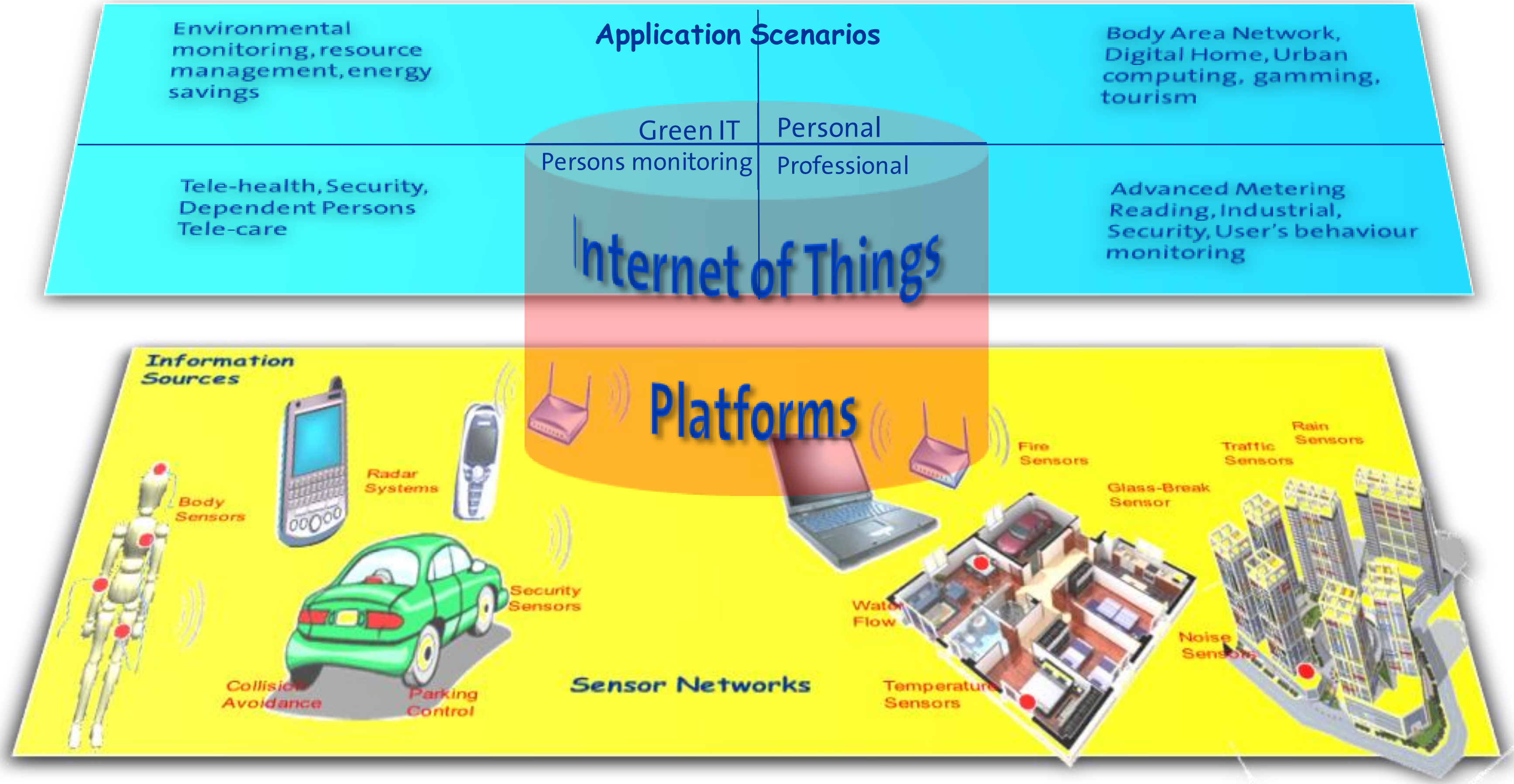
Chinese Premier Wen Ji
(August 2009)

互联网+物联网=智

Internet + Internet of Things =
of the Earth



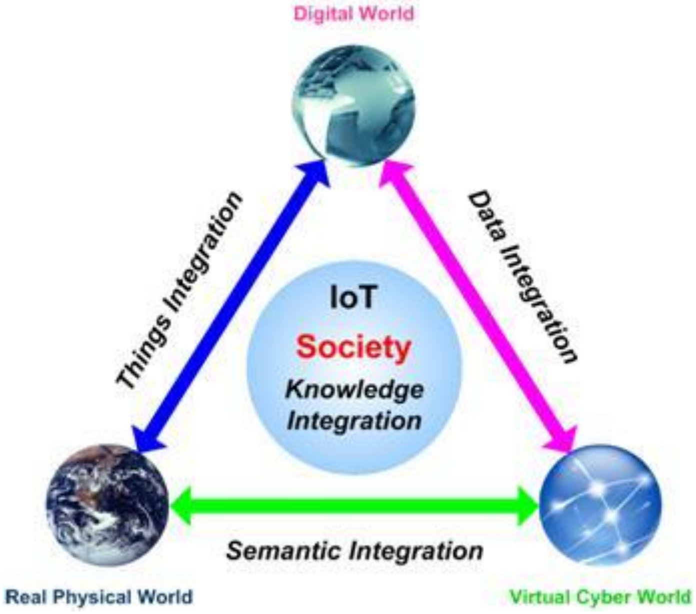
Internet of Things
Application Domains



Internet of Things

Technological Challenges (I)

- Number of devices and users
- Heterogeneity of edge devices
- Information flows and traffic patterns
- Mobility
- Information explosion and privacy
- Importance of metadata



CERP-IoT
Cluster of European Research Projects on the Internet of Things

Internet of Things

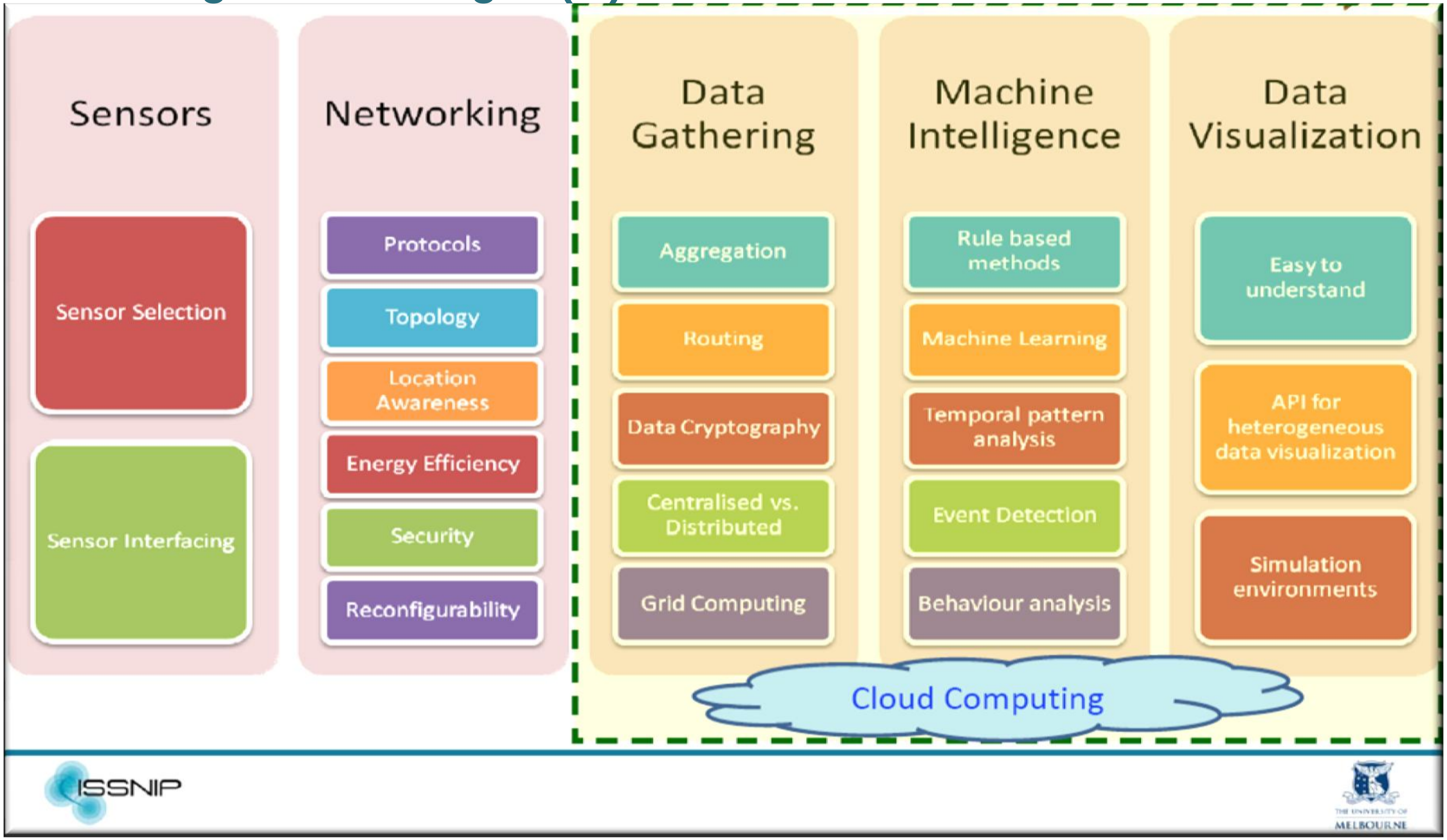
Technological Challenges (II)

User based interactions	Machine to Machine
Millions of connections	Trillions of connections
Little mobility	High mobility
Data	Information
User managed	Self managed

The Internet of Things needs an open architecture to maximise interoperability among heterogeneous systems and distributed resources including providers and consumers of information and services, whether they be human beings, software, smart objects or devices.

CERP-IoT
Cluster of
European Research Projects
on the Internet of Things

Internet of Things
Technological Challenges (III)



M. Palaniswami
Towards Sustainable Smart Cities - Role of Large Scale WSNs
ISSNIP - The University of Melbourne, Australia

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SENSEI EU Project

Facts

Coordinator:
Laurent Herault, CEA-LETI

Technical Manager:
Alex Gluhak, University of Surrey

Administrative Manager:
François Bourdel, ALMA CG

Title: Integrating the Physical with the Digital World of the Network of the Future

Budget:
23,332,896 €

EC funding:
14,977,717 €

Effort:
1879.3 PM

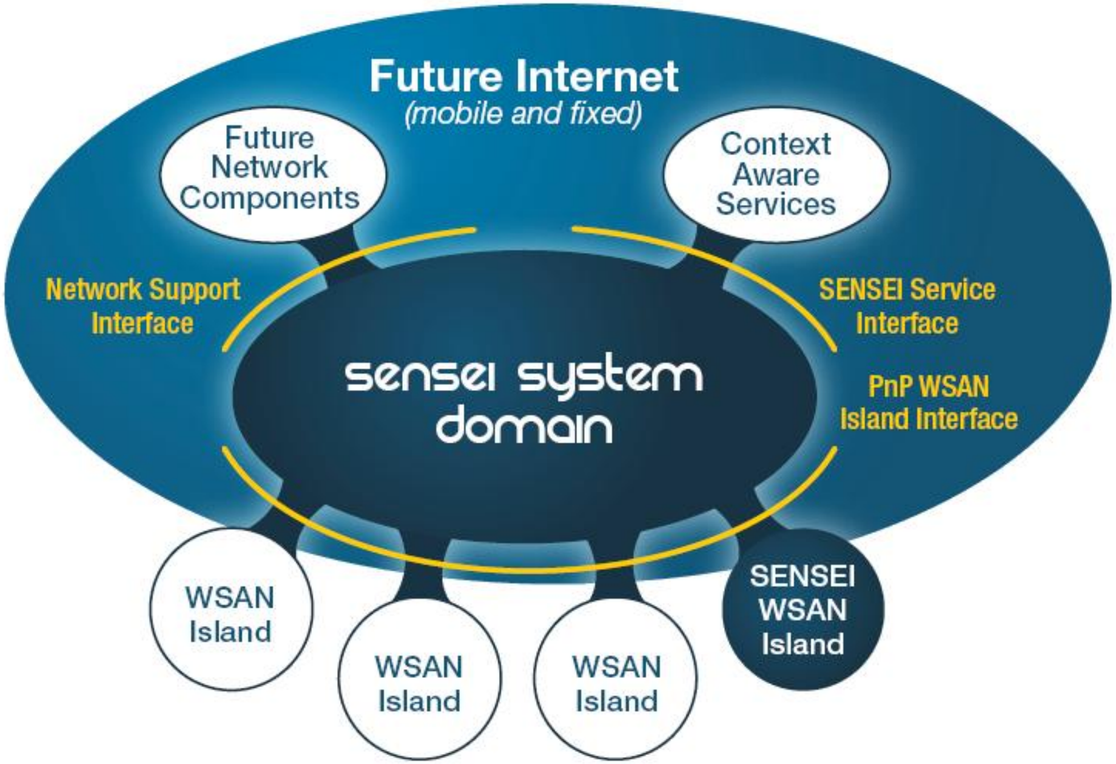
Period:
Jan 2008- Dec 2010

19 Partners in 12 EU countries:
- 9 Industrials
- 2 SMEs
- 2 Research Centres
- 6 Universities

SENSEI EU Project

Top Level Goals

- Design the foundations of a framework that enables an open market place for real world information and interaction
- Contribute this framework to the architecture for a Real World Internet



SENSEI Information - What

SENSEI EU Project

From Sensors to Context

- Sensor Information vs Context Information:
  - The Temperature of sensor nº 25 → Sensor Information
  - The Temperature of my garden → Context Information
- Context Modeling:
  - Tries to represent the universe of domain, the “world”
  - Is based on Entities (like for example persons, places, etc.) and characteristics of the Entities (like the temperature, etc.)
- Advantages of Context Modeling:
  - The development of final applications is simpler.
  - Automatic composition can be applied
  - New information can be inferred from the current one, etc.
- Disadvantages of Context Modeling:
  - Everything relies on the quality of the model:
    - **What happens if the current model does not handle the application needs?**
    - **How easy is for a sensor provider to assign a sensor to an entity in the model?**

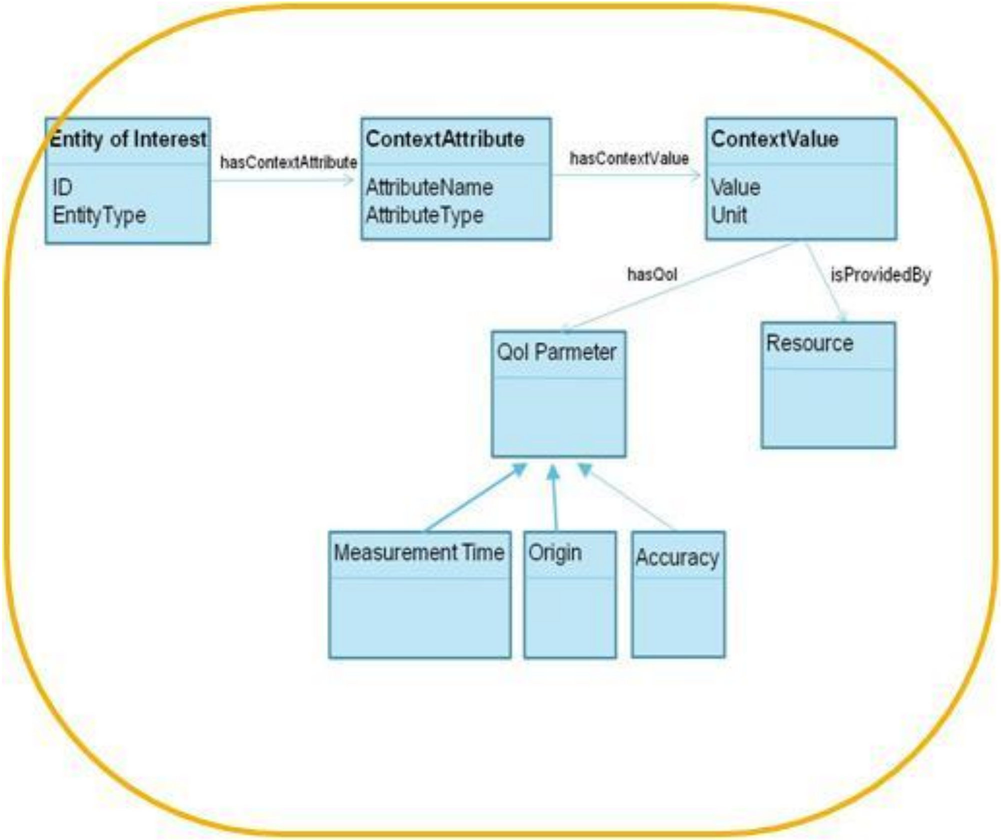
SENSEI EU Project

Information Model

Different kind of information available at different levels of details and abstractions:

→ **Three Level Information Modelling**

- Raw data value provided directly by sensor
- Observation and measurement augmented with meta Information, e.g., quality parameters provided by resource
- Context information: contextualization based on entity/attribute model provided by advanced components and context resources



Information Model

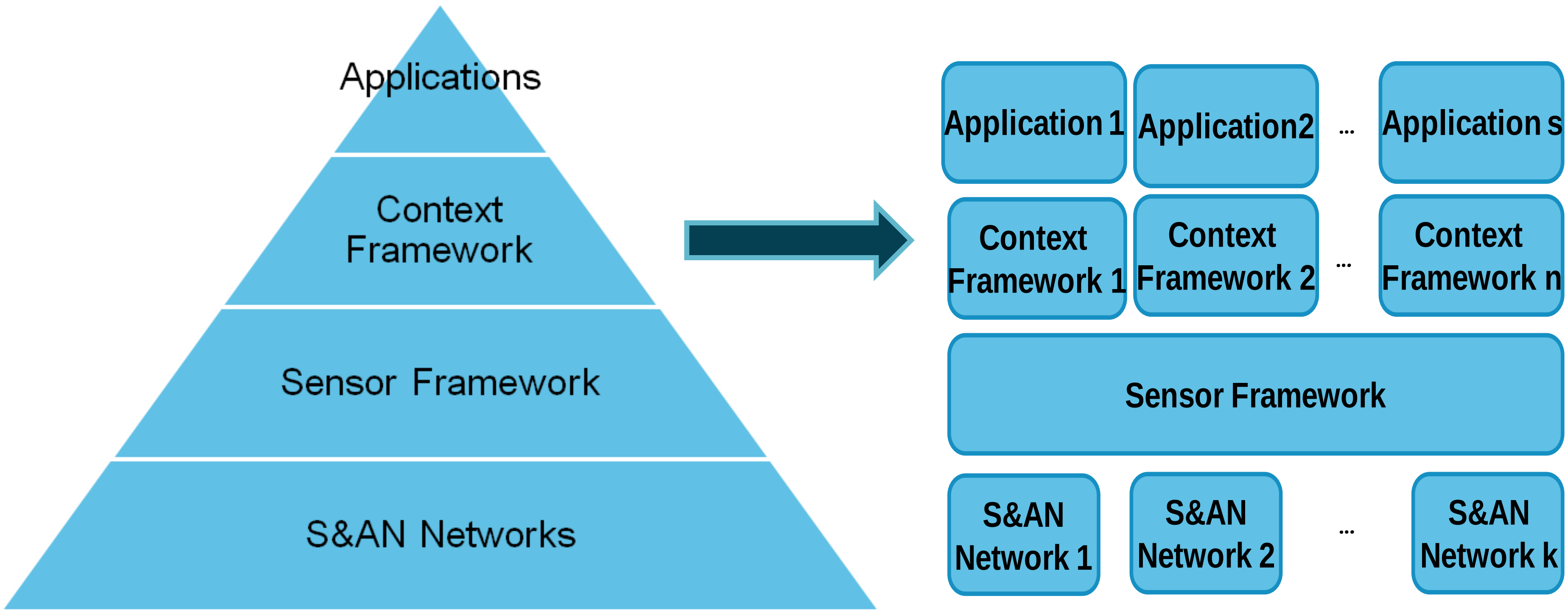
Architectural decisions – How

SENSEI EU Project

Sensei: Sensor Framework vs. Context Framework

- How can SENSEI provide sensor Information and Context information?
  - A Context Framework?
  - A Sensor Framework?

➢ Both: A Context Framework build on top of a Sensor Framework

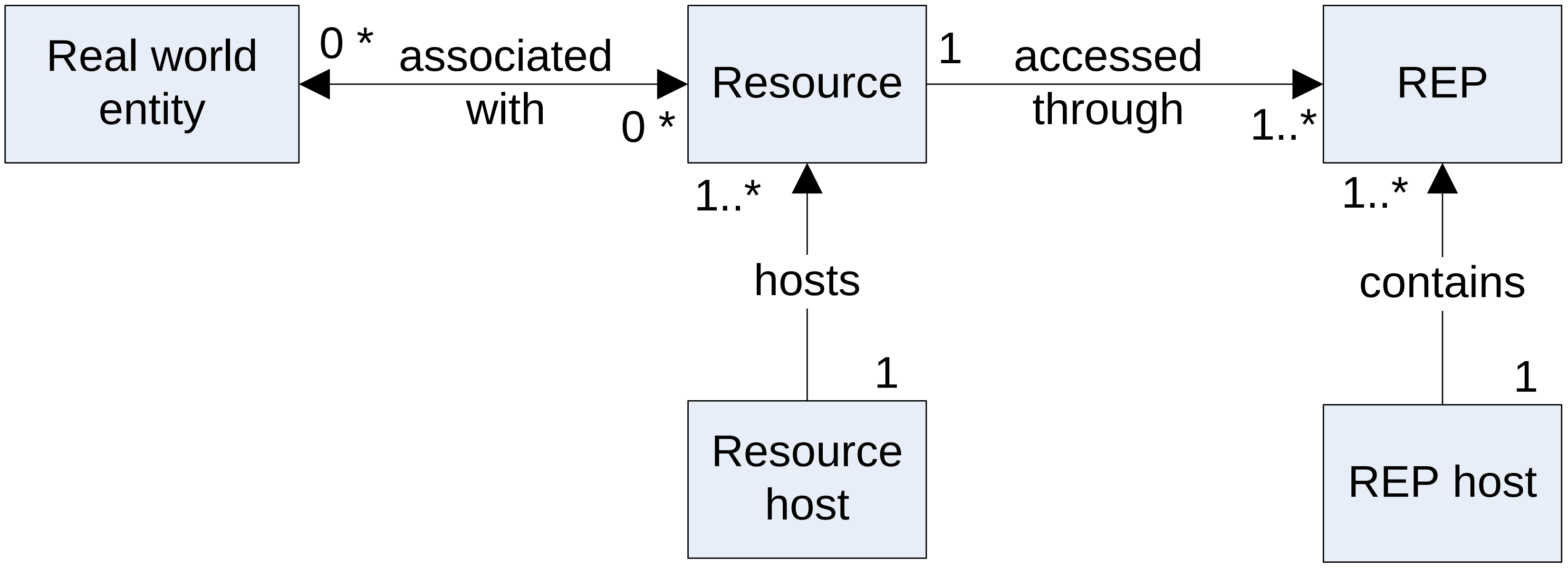


Resource Concept- Who

SENSEI EU Project

Resource concept

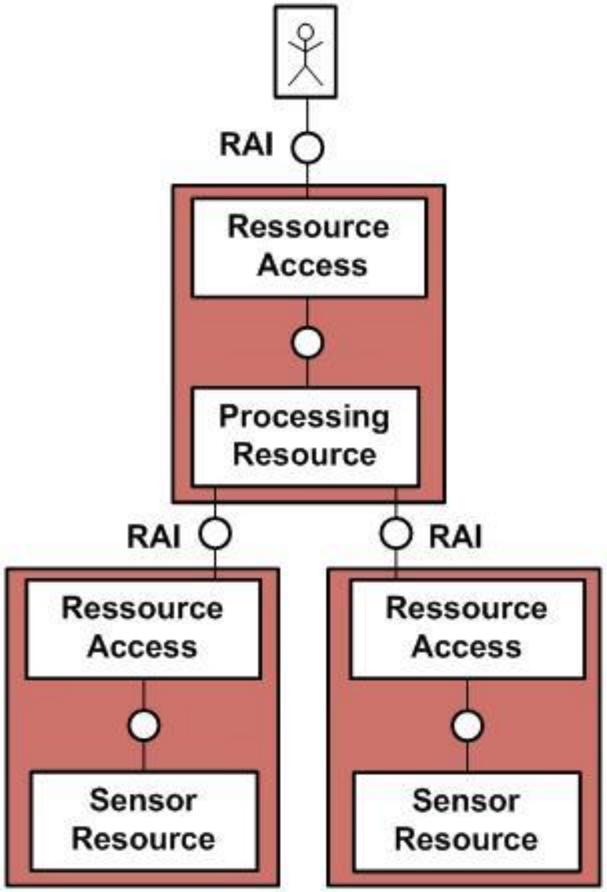
- Resource is a conceptual representation in the SENSEI domain of
  - any information source that can provide real world information
  - any interaction capability with the real world



SENSEI EU Project

Composite resources

- Resources can be combined and exposed as new resource end points
- Composition can span different WSAN islands
- Such composition can be static or dynamic at run time

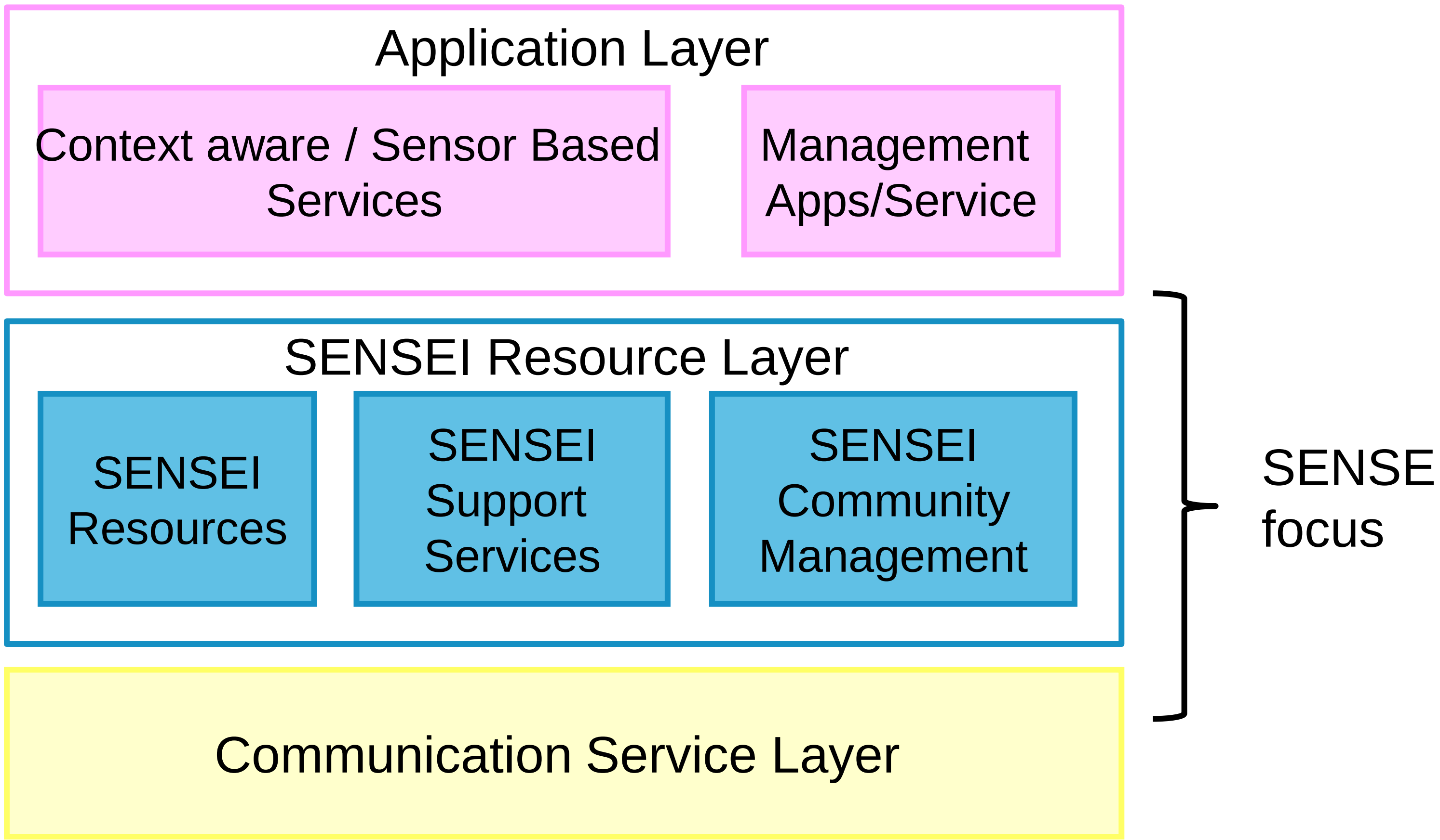


Support for heterogeneity

- Resources are uniform at the description level:
  - Basic resource description:
    - Identifier, name, etc.
    - Syntactic description of the interface to access the resource: WSDL, WADL, WIDL, etc.
    - Description of the basic capabilities.
  - Advanced resource description (optional).
    - Semantic description of the methods it provides
    - Semantic description of the data it manages.
- ... But they don't provide a uniform access interface.
  - Each resource decides what interface/s provides.
  - These interfaces are not standardized
  - This allows the easy integration of existing technologies.

SENSEI EU Project

High level overview



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Standardization Initiatives

- **Standards related to IoT**
- **ICT standardization for specific Green IT Domains**

Standardization Initiatives

- **Standards related to IoT**

- **ICT standardization for specific Green IT Domains**

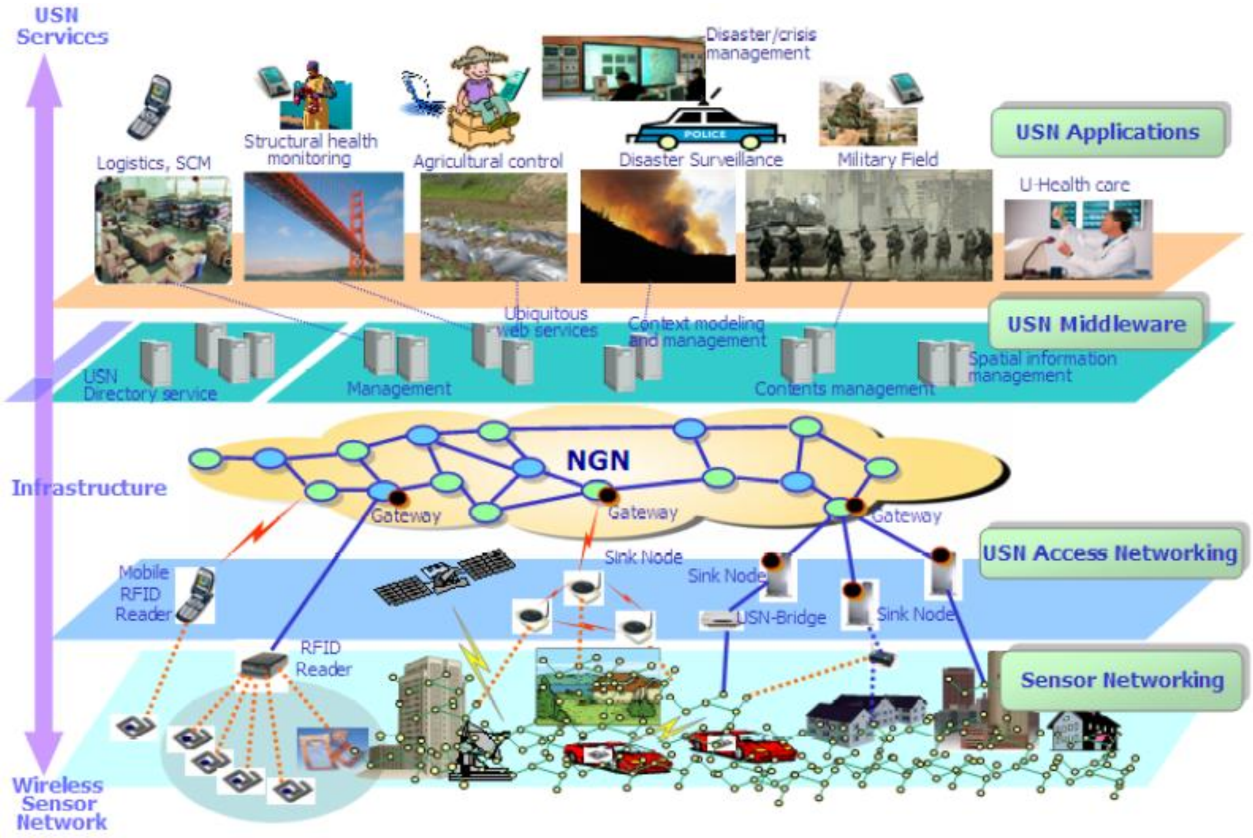
Standardization Initiatives

Standards related to IoT

Standardization Initiatives

Standards related to IoT: ITU's 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. »



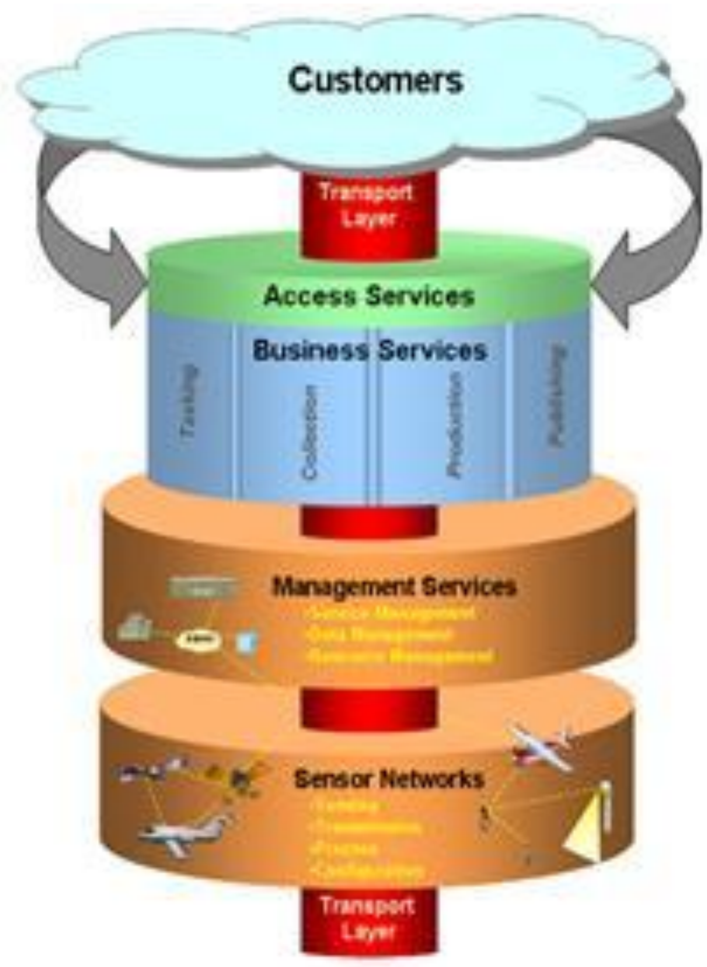
Standardization Initiatives

Standards related to IoT: ISO JTC1

WGSN – WG7

working group on sensor network

ISO JTC1 IEC
INFORMATION TECHNOLOGY STANDARDS

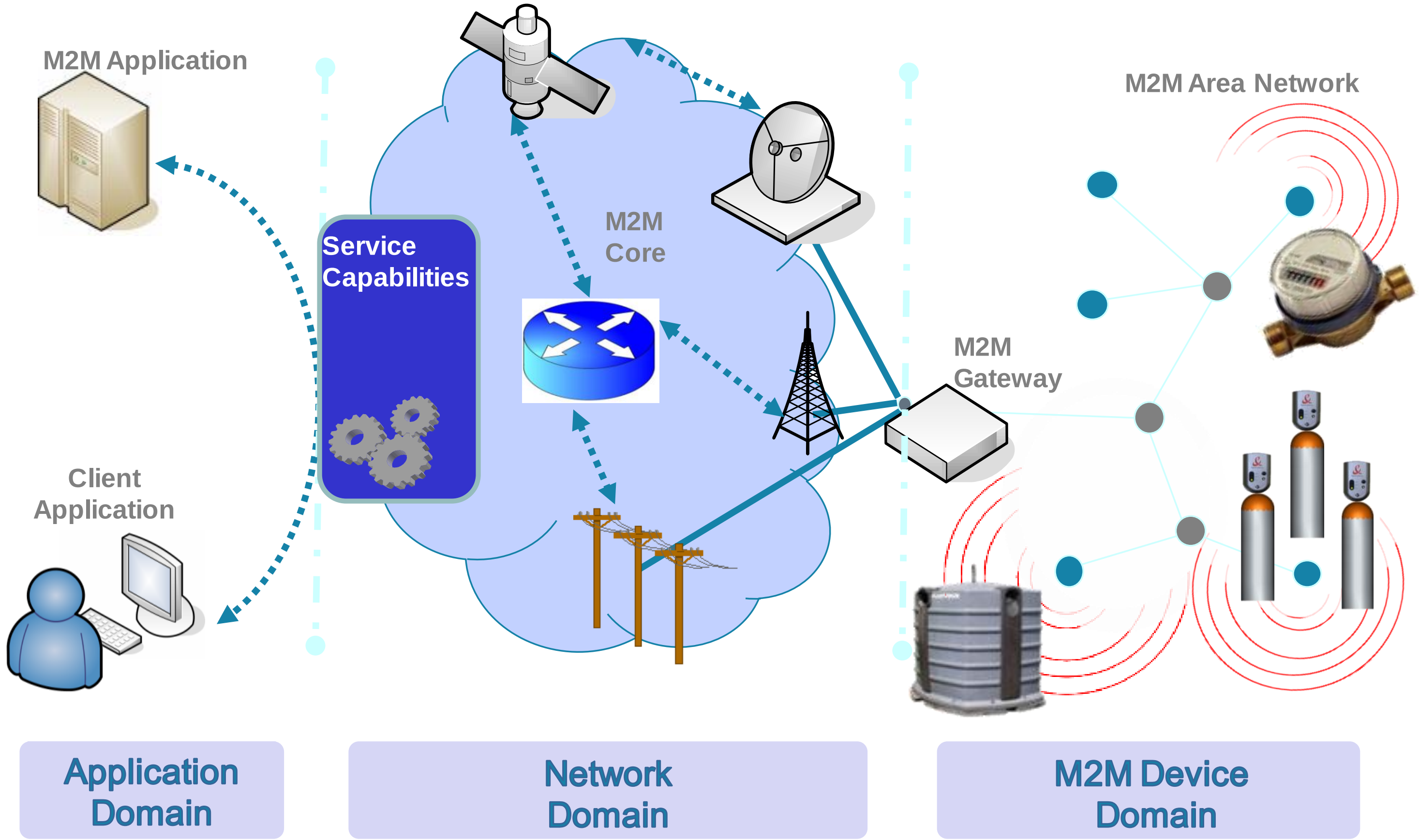


Standardization Initiatives

Standards related to IoT: ETSI TC M2M

ETSI TC M2M

- To collect and specify M2M requirements from relevant stakeholders.
- to develop and maintain an end-to-end overall high level architecture for M2M.
- to identify gaps where existing standards do not fulfill the requirements and provide specifications and standards to fill these gaps, without duplication of work in other ETSI committees and partnership projects.

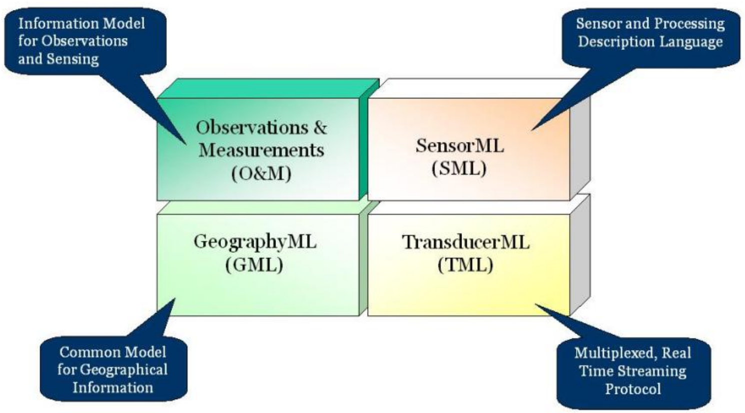


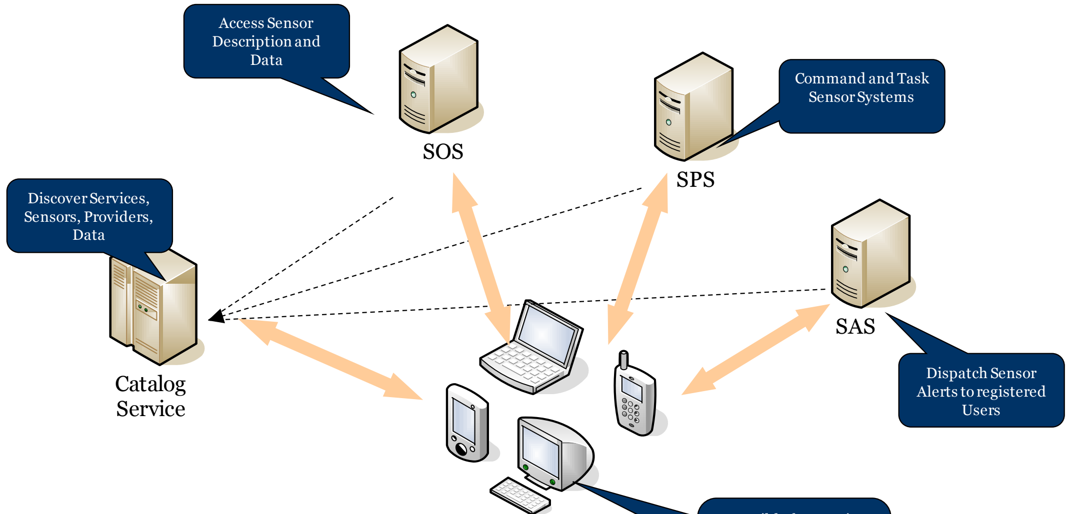
Standardization Initiatives

Standards related to IoT: OGC® SWE™

Open Geospatial Consortium Sensor Web Enablement

- OGC® is an international industry consortium of more than 330 companies, government agencies, research organizations, and universities.
- Need for a broad set of critical real world information interoperability.
- Sensor Web Enablement (SWE) enable developers to make all types of sensors, transducers and sensor data repositories discoverable, accessible and useable via the Web.



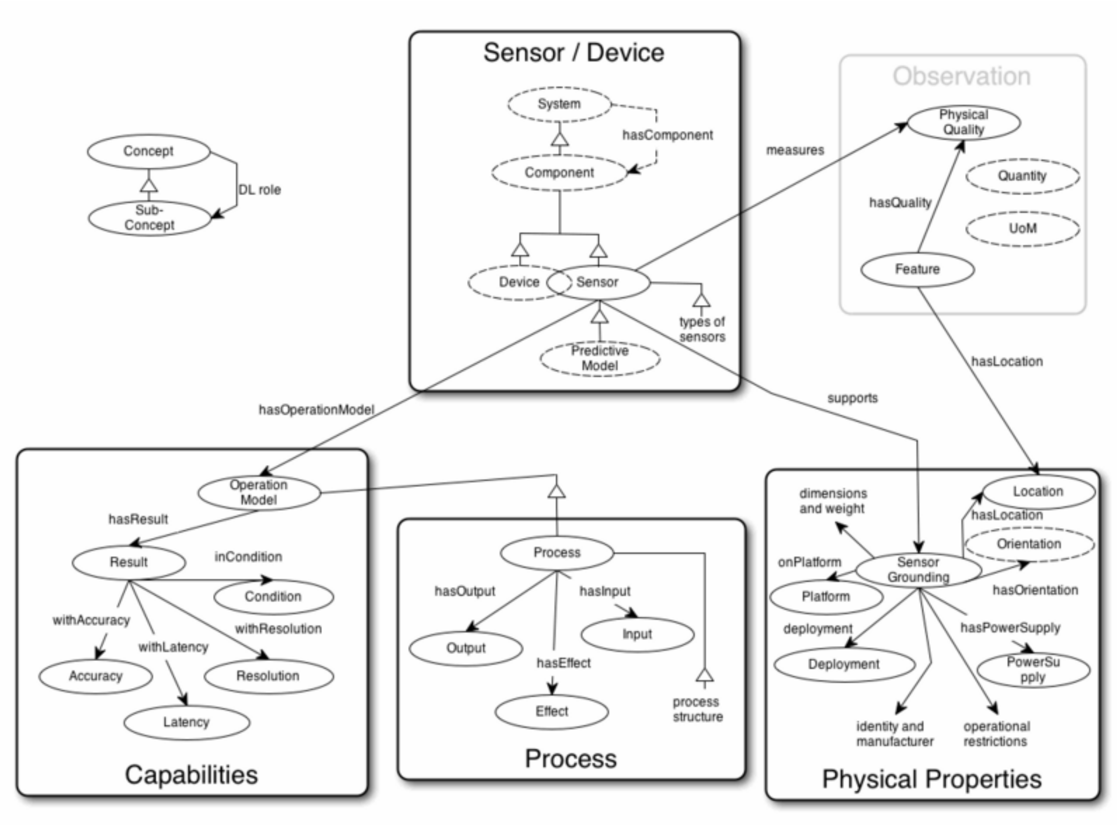


SWE Components – Web Services

Standardization Initiatives

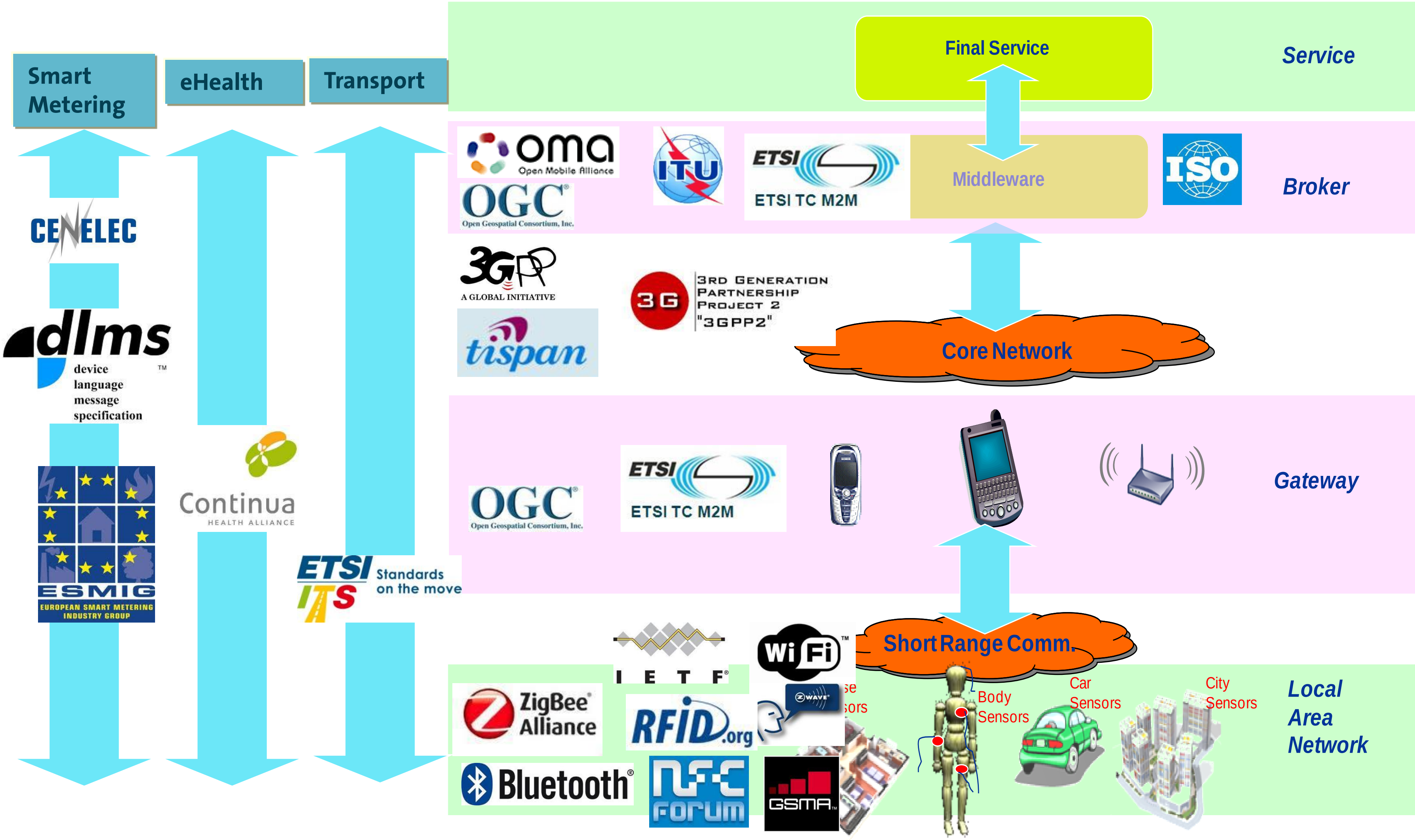
Standards related to IoT: W3C Incubator Group SSN-XG

- **W3C Incubator Group on Semantic Sensor Networks** Launched (March 4th, 2009)
- The SSN-XG will work on two main objectives:
  - the development of ontologies for describing sensors, and
  - the extension of the Sensor Markup Language (SensorML), one of the four SWE languages, to support semantic annotations.



Standardization Initiatives

Is the standards harmonization possible?



Standardization Initiatives

- Standards related to IoT
- **ICT standardization for specific Green IT Domains**

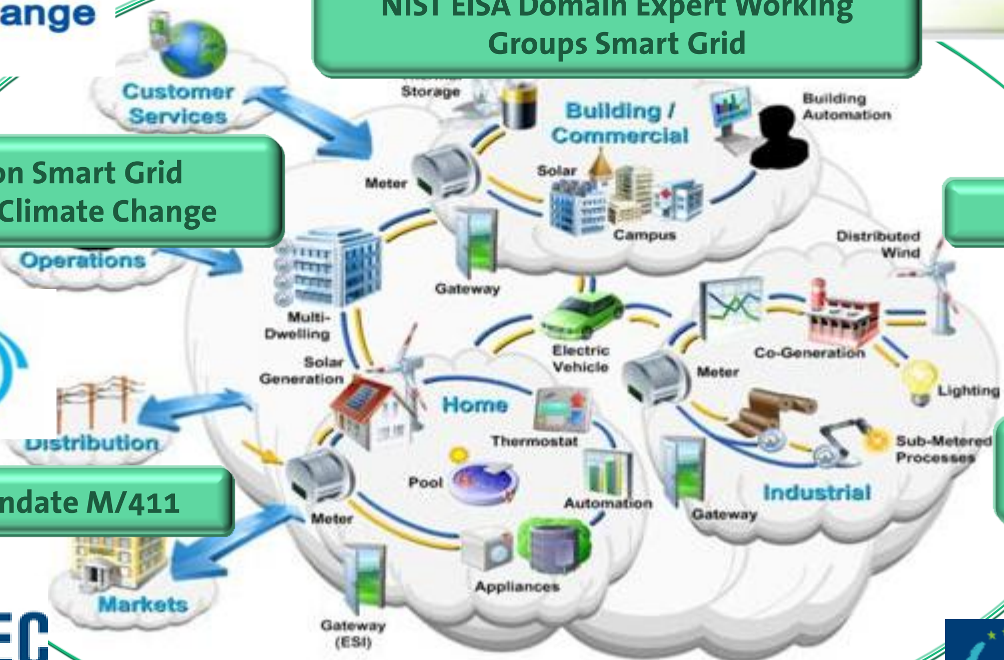
Standardization Initiatives

ICT standardization for specific Green IT Domains

NIST EISA Domain Expert Working Groups Smart Grid

ITU-T Focus Group on Smart Grid
ITU-T Environment & Climate Change

Korea Smart Grid Association



State Grid Corporation of China

Smart Metering EC Mandate M/411

EC Initiatives

JTC 1 SWG Special Working Group Smart Grid

Smart Grid Strategic Group

Internet of Things:
A main driver for a true Green IT?

The prevailing assessment of positive and negative effects will depend on how effectively energy and waste policy governs the development of ICT infrastructures and applications in the coming years

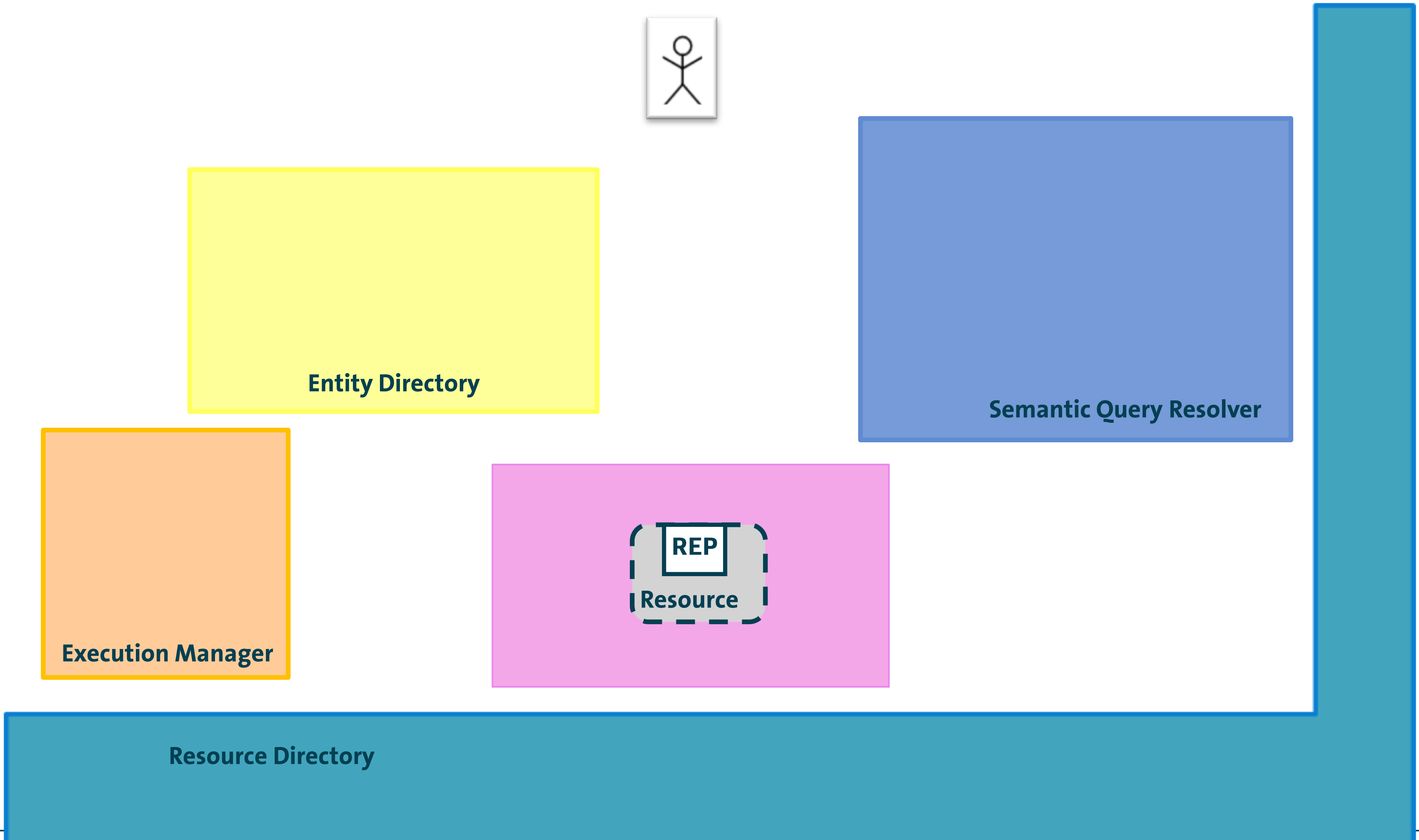
Andreas Köhler and Lorenz Erdmann
Expected Environmental Impacts of Pervasive Computing
Human and Ecological Risk Assessment: An International Journal, vol. 10, 2004

Think Green!
Be Green!
Research for Green!

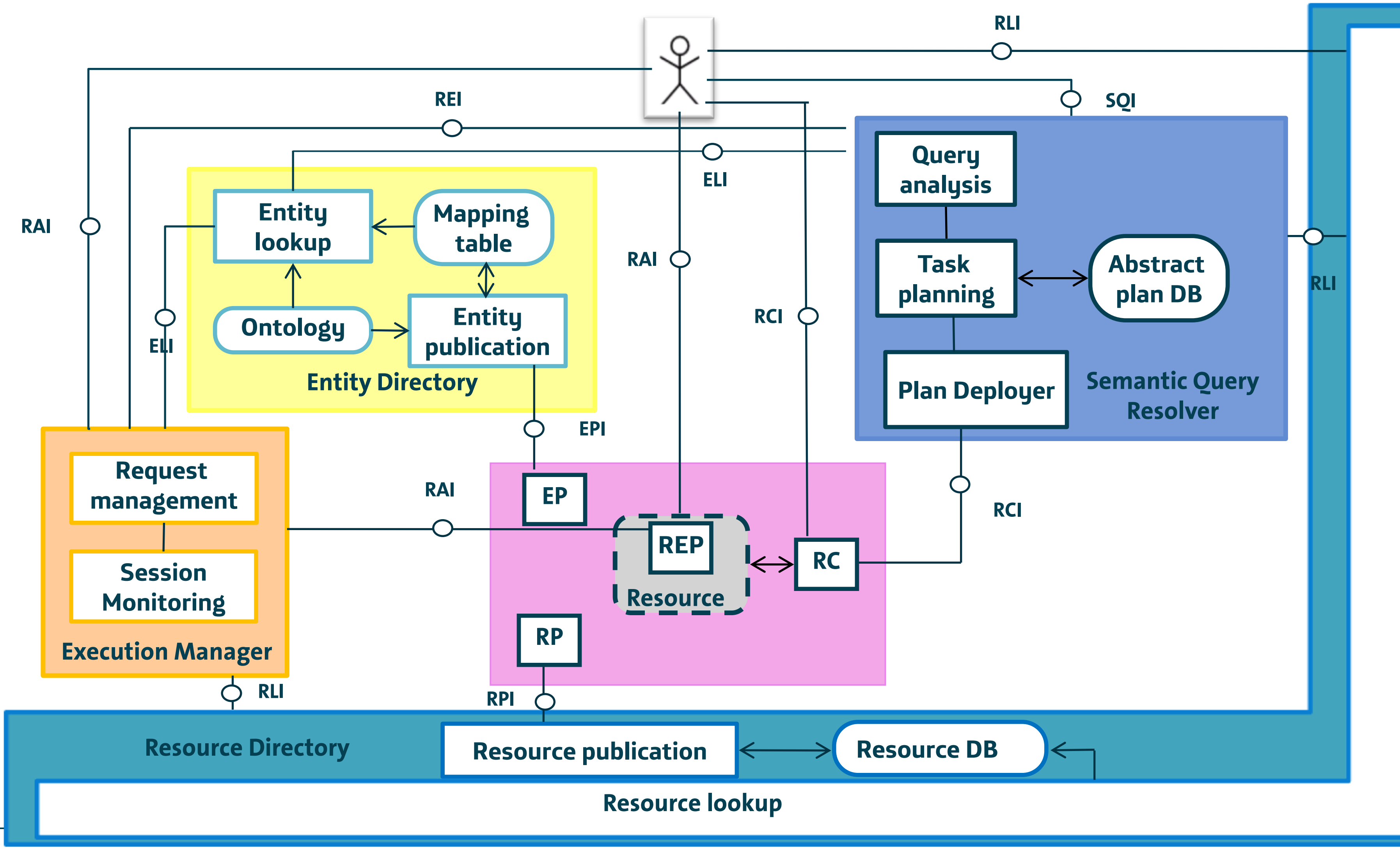
Thank You!

bernat@tid.es

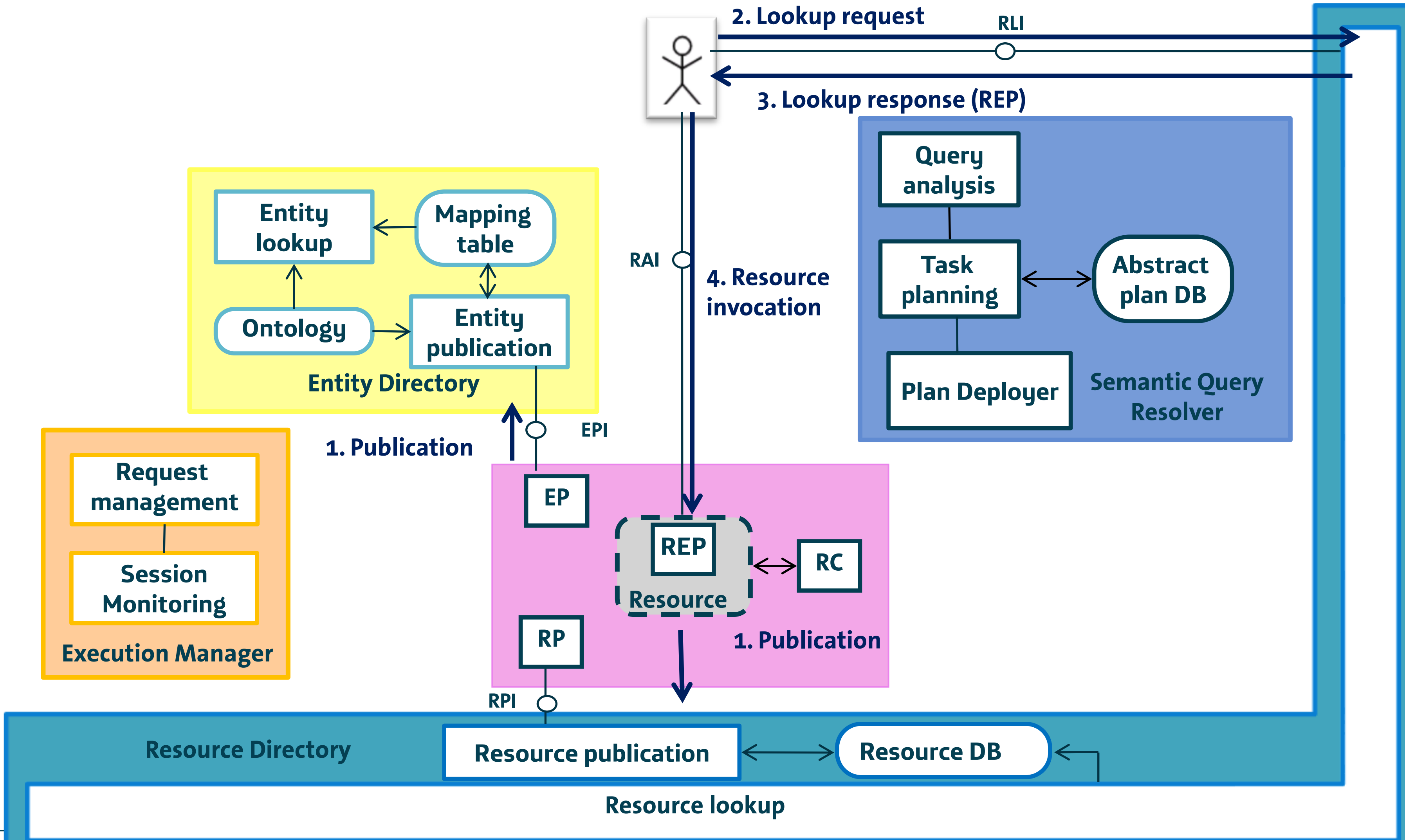
System components – high level view



System components – network view



System interactions – registration and simple lookup



System interactions – resource query