Middleware for Internet of Things (IoT)

<< More than the sum of its devices, the Internet of Things links technologies together to create new services and opportunities. >>

Course (2 ECTS)

For Master II IFI and Ubinet, and Polytech-SI5

Web Pages : www.tigli.fr/doku.php?id=cours:mit_2017_2018

Video

- Everytime, Everywhere, but also ... Everything
- In our everyday life

- Sensor Network https://www.youtube.com/watch?v=Mij_Ge3f8tw&feature=youtu.be

But not only ...

- Ambient Comp for everyday life with connected Objects
- http://www.dailymotion.com/video/xqj9gm_ambientcomp-integrateur-gb-hd_tech

- In french ... Continuum for worker on the field with connected Objects
- http://www.dailymotion.com/video/x2bnts6_continuum-version-courte_tech

TEST your own Background

MCQ – Multiple-choice questionnaire

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Is it new ?
Ubiquitous Computing (1991)

« Silicon-based information technology, is far from having become part of the environment »

- ▶ Everytime, Everywhere, but in Everything

- ▶ Ubiquitous Computing is a Post distributed Distributed Computing

- ▶ After networks of distributed computers, mobiles computers, it's time for distributed « Things » and anything connected.

From Von Neumann Computer Model to connected Objects ....
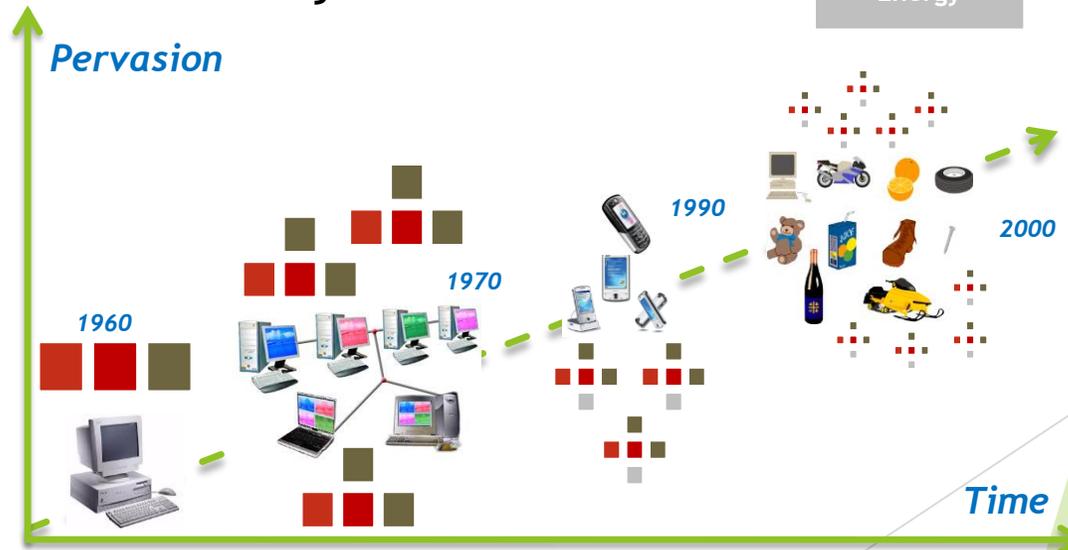
Mark D. Weiser (chief scientist at Xerox PARC in the United States) ... since 1991 has talked about "the computer for the 21st Century"

IoT in a … cloud of keywords about a same idea…

- ▶ Ubiquituous Computing
- ▶ Pervasive Computing
- ▶ Disappearing Computing
- ▶ Internet of Things
- ▶ Machine to Machine
- ▶ Cyber Physical Systems
- ▶ Web of Things

Internet of Things

Inputs / Outputs

Connectivity

Interoperability Challenge

Internet of Things

Inputs / Outputs

Connectivity

Interoperability Challenge

What are Things ?

- **Mainly based on Inputs / Outputs sophistication …**

- Things are connected Devices

- More or less sophisticated
  - Connected Sensors
  - Connected Actuators
  - Connected Objects (with sensors and actuators)

- At first they were sensors …
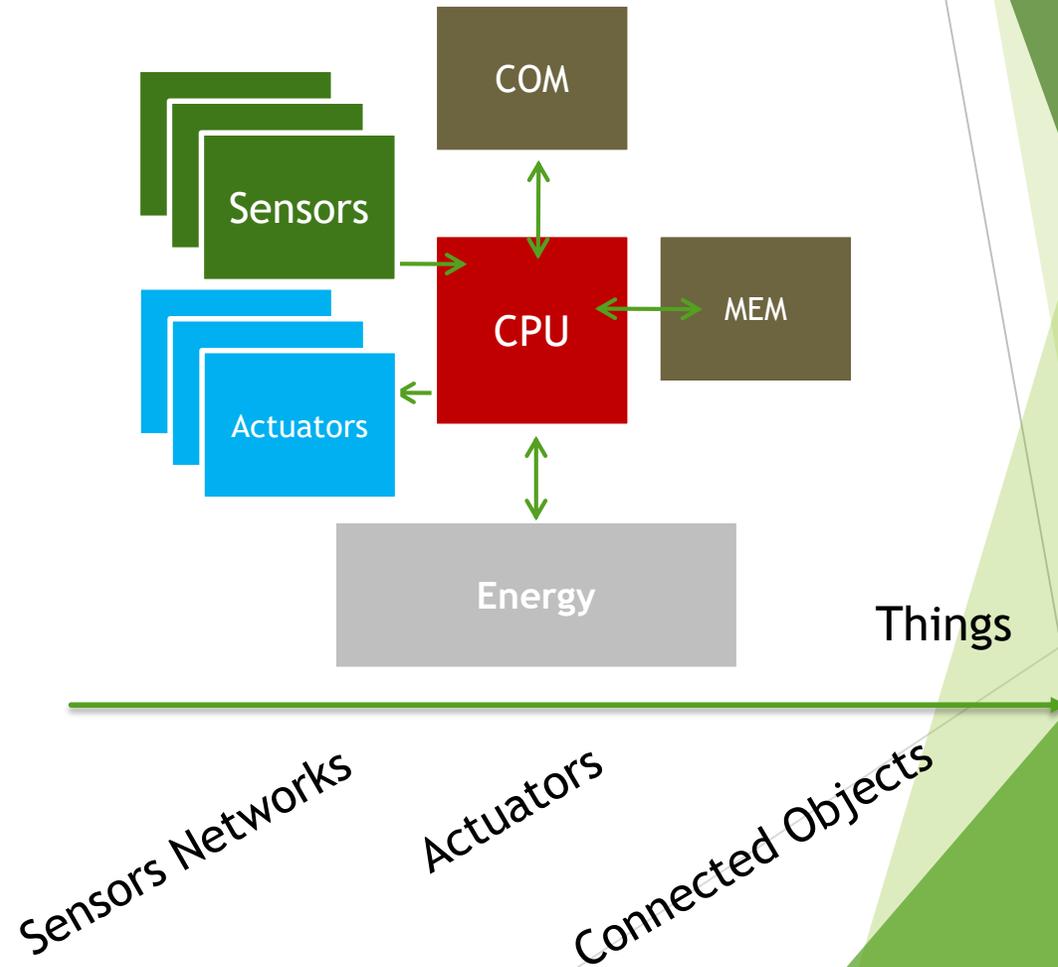
What are Things ?

- At first they were sensors ...
- To collect Data on the field
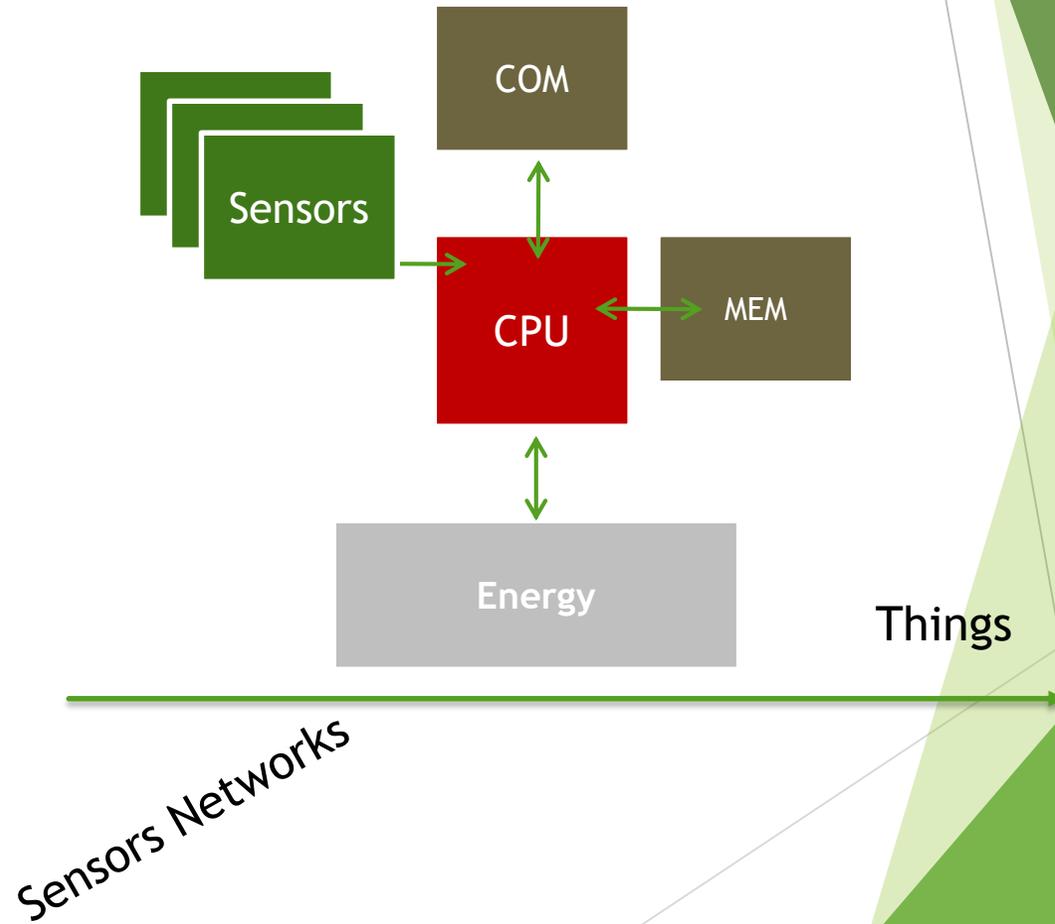
What are Things ?

▶ Actuators were added ...

▶ To collect Data and Control Devices on the field
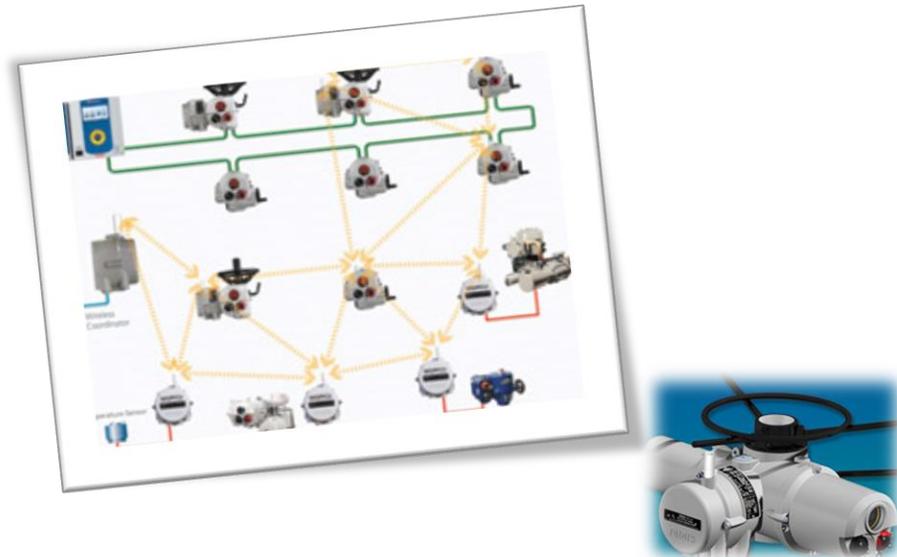
Wireless Control for Valve Actuators

Things

Sensors Networks

Actuators
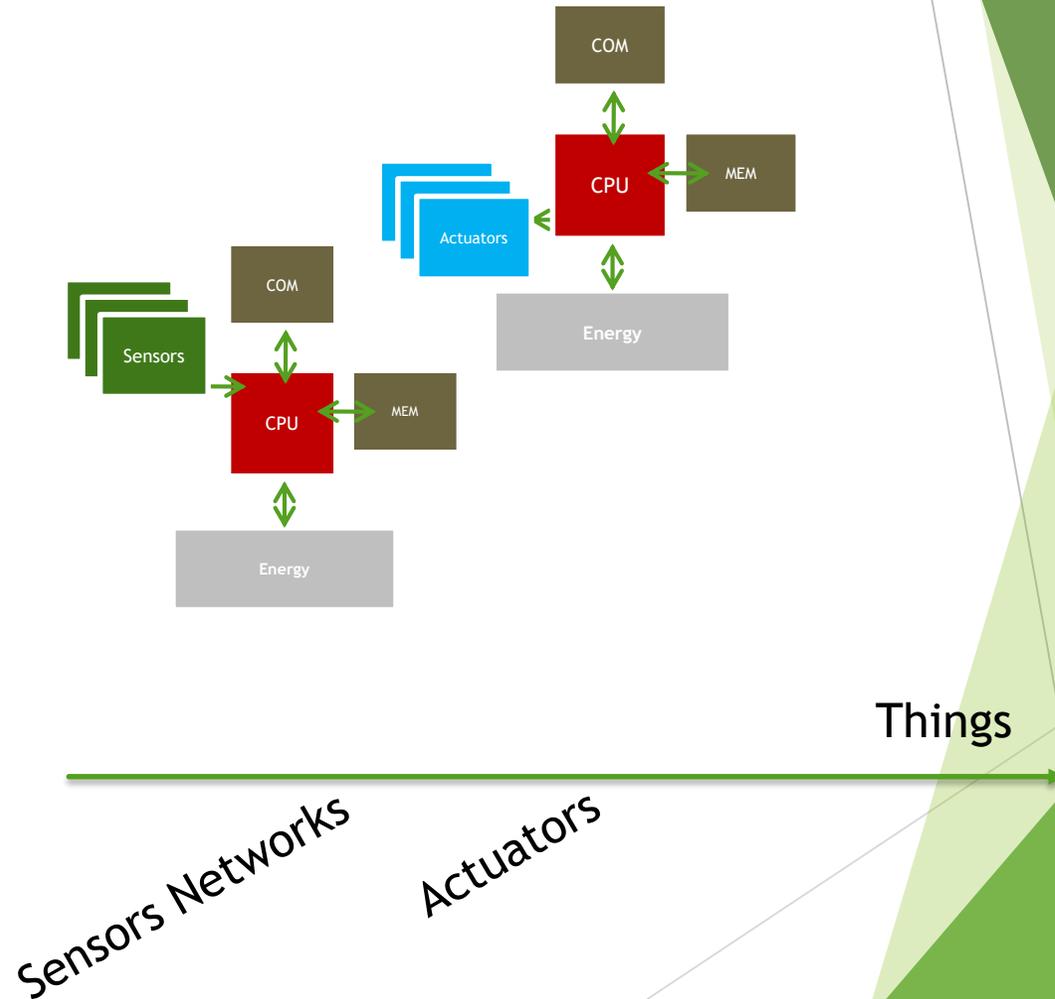
What are Things ?

- ▶ And they became Connected Objects ...

- ▶ To collect Data, to Control Devices on the field and much more around you

COM

Sensors

CPU

MEM

Actuators

Energy

Things

Sensors Networks

Actuators
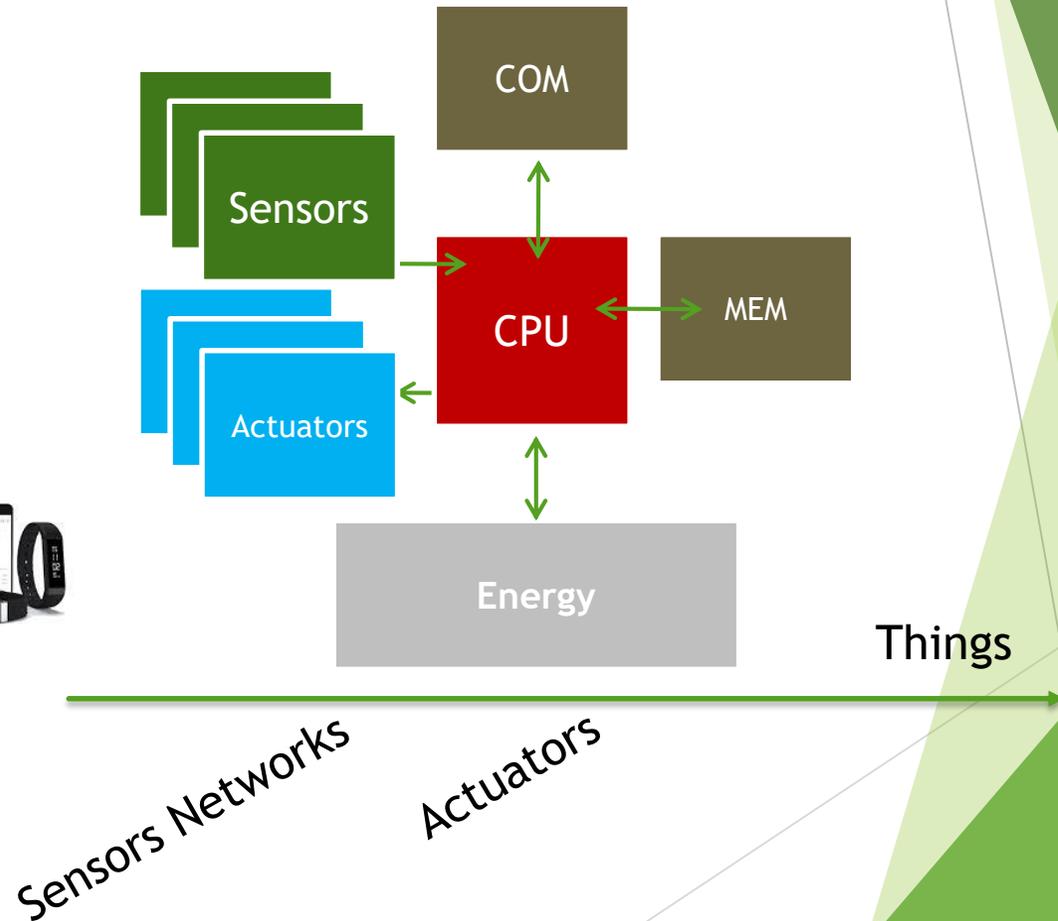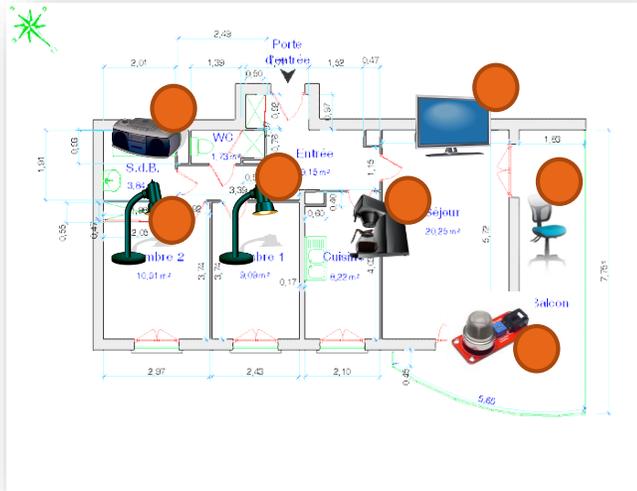
Don't forget … IoT is not IoS (Internet of Sensors)

Internet of Things

Inputs / Outputs

Connectivity

Interoperability Challenge

Connectivity and OSI / ISO Model

- Internet is much more a protocol vision on the OSI/API Stack

- Classical approaches :

  - Wired or Wireless, Local Area Networks

  - Internet to federate these heterogeneous technologies

Couches OSI

Application
Présentation
Session
Transport
Réseau
Liaison
Physique

Couches TCP/IP

| |
|---|
| Application |
| Transport (UDP,TCP) |
| Internet (IP) |
| Interface |
| Matériel (IEEE 802) |
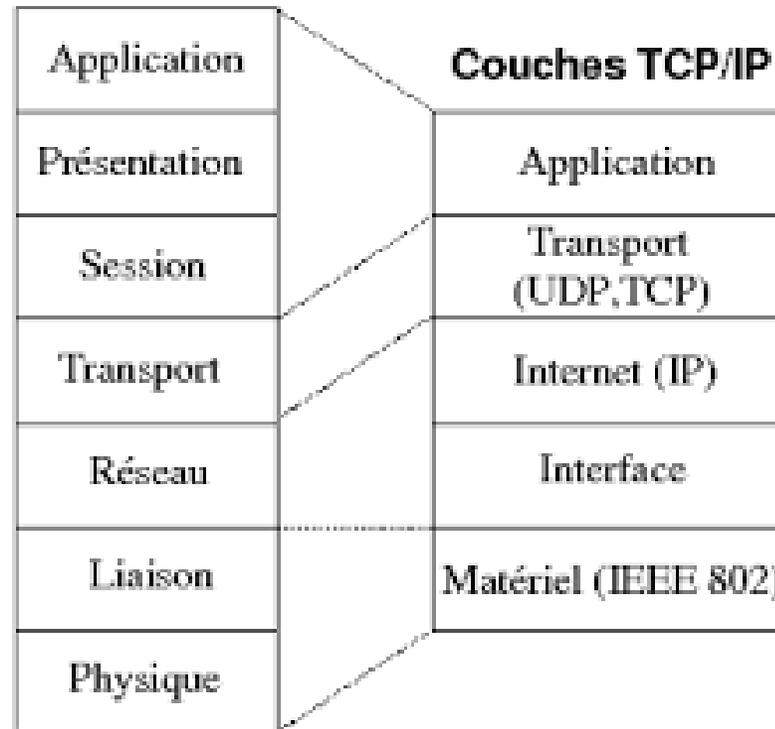
ITU-T Study Group, "New ITU standards define the Internet of Things and provide the blueprints for its development," ITU, 2012. [Online]. Available on http://www.itu.int/en/pages/default.aspx.

New challenge for Connectivity

- Internet of Things as « Network of networks of Things » (gateways between heterogeneous protocols)

- Internet of Things as « Things over Internet » (gateways toward common internet protocol)

Gateways and High Level protocols for Interoperability over IP ...

LAN, WLAN
But also
BAN, PAN, LPWAN

Give us some examples for BAN, PAN, LPWAN ...

Couches OSI

| Application |
| Présentation |
| Session |
| Transport |
| Réseau |
| Liaison |
| Physique |

Couches TCP/IP

| Application |
| Transport (UDP,TCP) |
| Internet (IP) |
| Interface |
| Matériel (IEEE 802) |
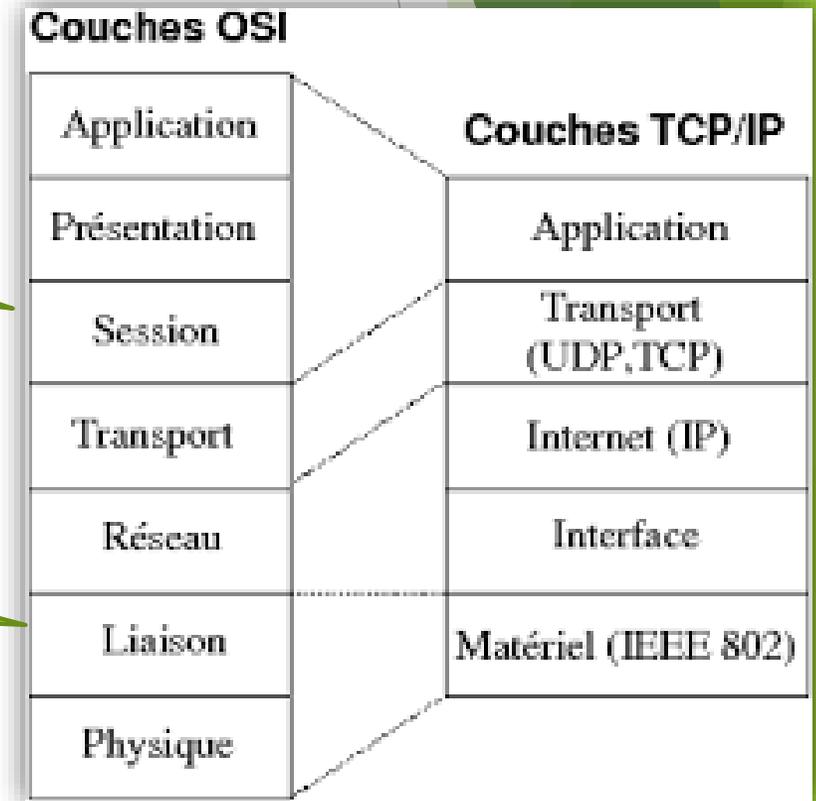
Internet of Things

Inputs / Outputs

Connectivity

Interoperability Challenge

Levels of interoperability

Not only for softwares and computers …

Legal	• Aligned legislation and legal meaning
Organisational	• Coordinated processes
Semantic	• Preservation of precise meaning of information
Technical	• Technical linking of systems

Middleware

Source: EIF, http://ec.europa.eu/isa/documents/isa_annex_ii_eif_en.pdf

Technical Interoperability Challenge : Too many standards at the IP level

- ▶ Classicaly Internet allow to federate heterogeneous specific networks

- ▶ But Internet is not enough to garantee interoperability

- ▶ This is only a common Network and Transport protocol ...

- ▶ Nothing about syntactic, lexical and semantic interoperability

- ▶ Some exceptions according to popularity : ex. MQQT (event based middleware)
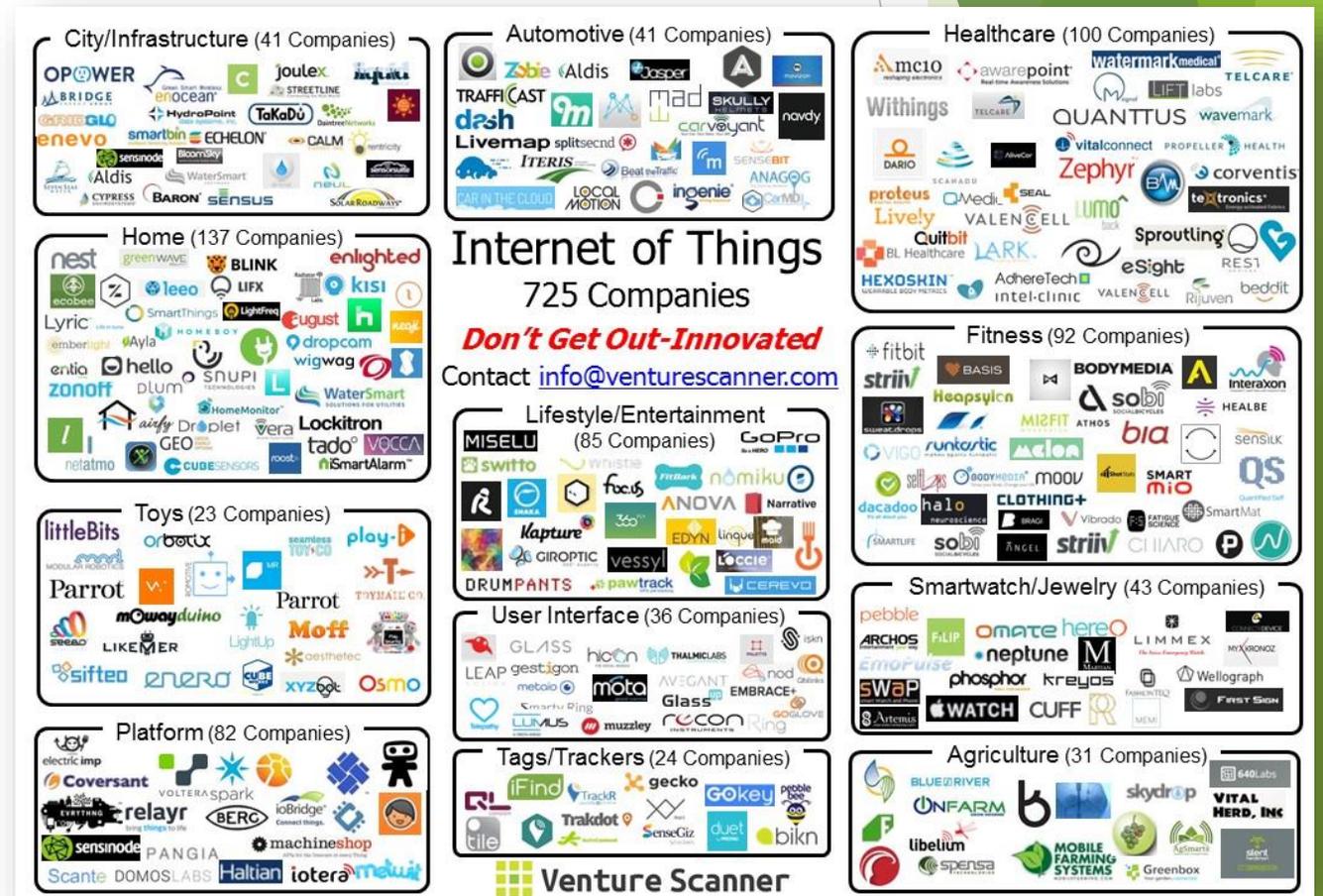
Technical Interoperability Challenge : Toward Web of Things with two trends ...

- First Trend is « Web of Physical Data »
  - How to integrate Things in the Web
  - How to add physical data as physical hyperlink
  - In a ROA (Resource oriented Architecture) style
  - Well adapted for CPS

- Second Trend is « Web of Physical Devices »
  - How to over overcome the limitation of the specificity of API
  - How to explicitly describe the API of a Service
  - In a SOA (Service oriented Architecture) style

Technical Interoperability : Web of Things and Devices to bypass the Technological Heterogeneity in IoT …

- WoT are Web-based solutions

- Web Services a good way to solve IoT heterogeneity through Gateways (or any other federative protocol with same properties)

- RESTFul, WS-SOAP, CoAP …

- If alternative solutions exist, they depend on the popularity of the standard of the communication protocol that they adopt
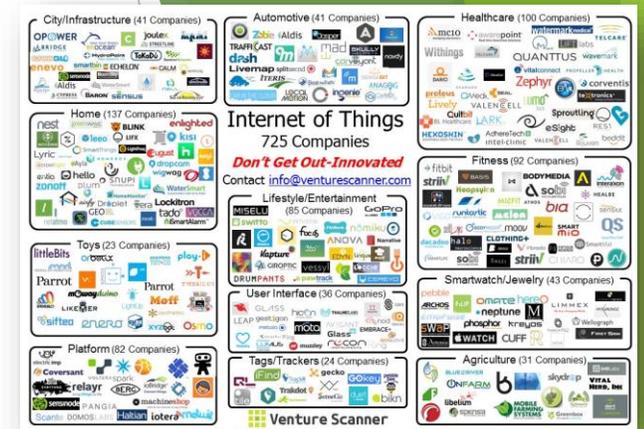
| Web of Things WoT | HTTP, REST,… |
| IoT | BT, ZigBee, 6LoWPAN,… |

Need to manage Technological Heterogeneity for communicating with devices

Things are ….

Example of Technical Solution : Web of Things for Physical Data or Physical Process

- ▶ The Web of Things (WoT) is a term used to describe approaches, software architectural styles and programming patterns that allow real-world objects to be part of the World Wide Web.

- ▶ WoT based on Resource oriented Architecture for CPS (Cyberphysical Systems for physical data)
  - ▶ RESTFul services to get Physical data with URI

- ▶ WoT based on Service oriented Architecture for CPS (Cyberphysical Systems for physical process)
  - ▶ SOAP services to access to physical devices functionalities

6th International Workshop on the Web of Things: WoT 2015, collocated with IoT 2015 and will take place at the COEX Center in Seoul, South Korea on October 2015 – http://webofthings.org/

Guinard, Dominique; Trifa, Vlad; Mattern, Friedemann; Wilde, Erik (2011). From the Internet of Things to the Web of Things: Resource Oriented Architecture and Best Practices. Springer. pp. 97–129. ISBN 978-3-642-19156-5.

Semantic Interoperability between WoT

▶ From Web Semantic

▶ Trough Web of Things

▶ Semantic Web of Things

   ▶ Knowledge about Context

   ▶ Knowledge about API

   ▶ How to manage and reason on them

The word semantic stands for the meaning of.	The semantic of something is the meaning of something.	The Semantic Web = a Web with a meaning
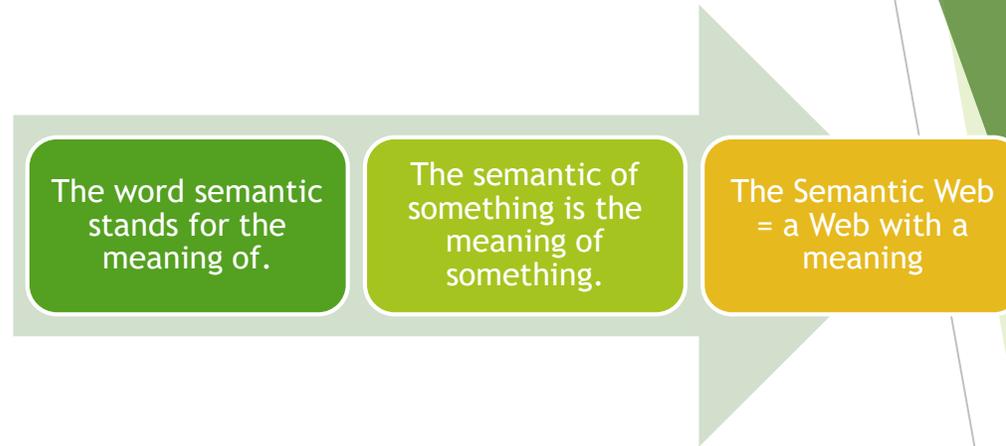
IoT application domains

Do not try to count !!!!

IoT application domains and related applications ...
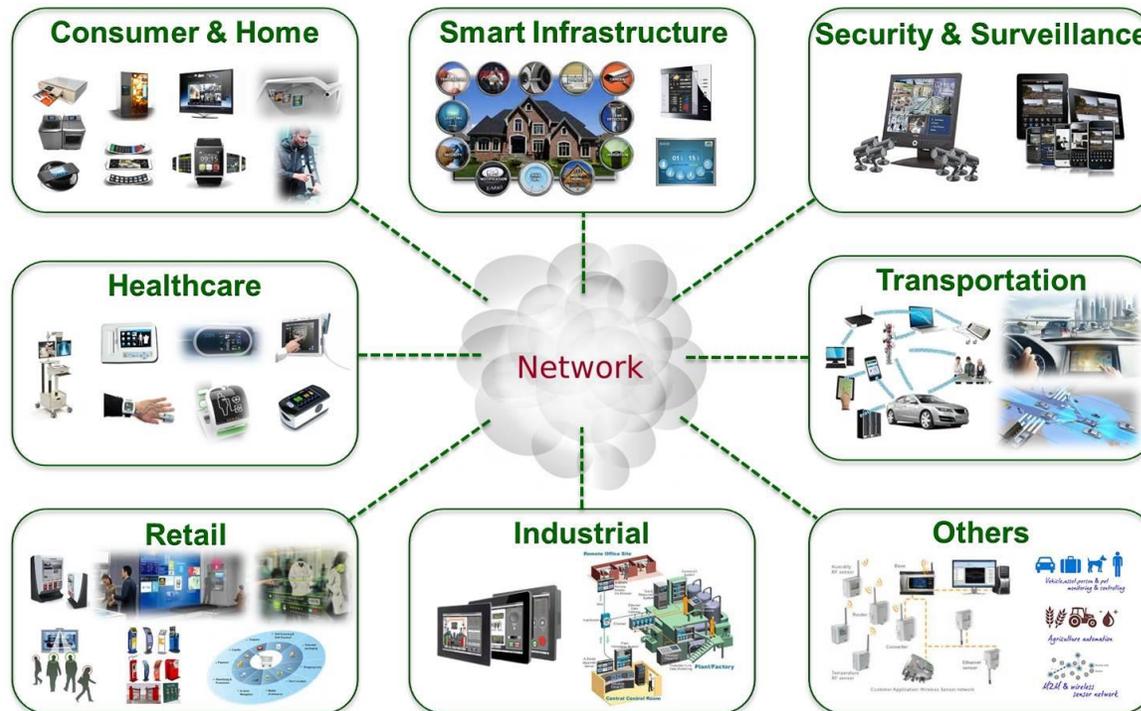
And more …
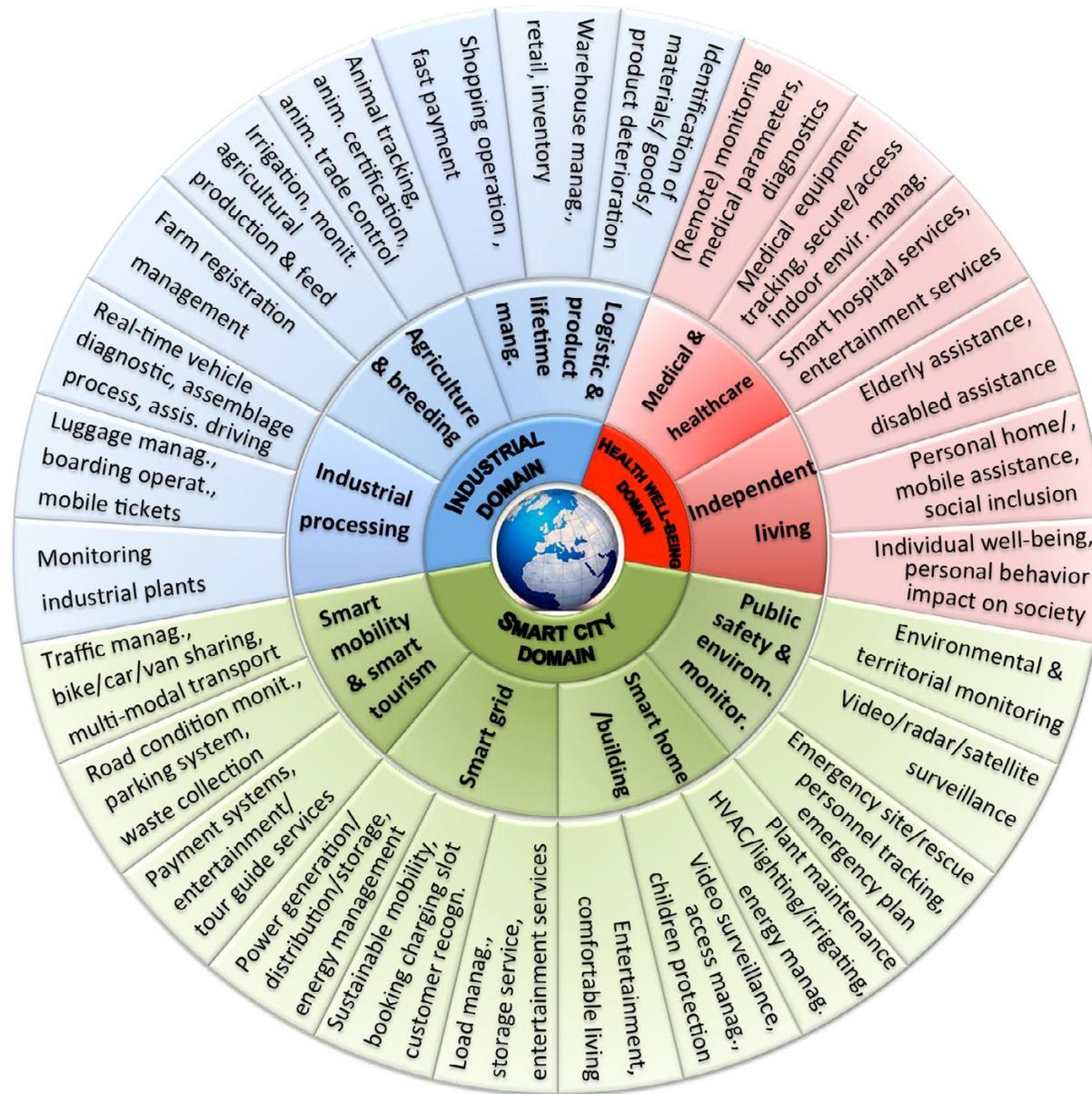
The Internet of Things vision: Key features, applications and open issues
Eleonora Borgia
Institute of Informatics and Telematics (IIT), Italian National Research Council (CNR), via G. Moruzzi 1, 56124 Pisa, Italy
Computer Communications 54 (2014) 1–31, paper

MIT Agenda

2017 - 2018

Main structure of the course

Middleware for IoT provide solutions

► For Interoperability challenges at different levels for IoT

► To Give answers to specific IoT constrains :

  ► Low power

  ► Limited Bandwith

  ► Large Area

  ► …

Main structure of the course and levels of interoperability

IoT Interoperability levels in the course
Advanced IoT : Semantic Web of Things (SWoT) and opportunistic composition
WoT and WSD : Web of Things and Web Service on Device – Tutorials : REST over Device and WoT and WSD composition
IoT : Network of Networks of Things – Tutorials : Things over IP (MQTT standard) and Complex Event Processing
Local and Personal Area Networks but also Body and Low Power Wild Area Networks – Tutorial LoRa

MIT Agenda and Lecturers

Session 1		
09:00-12:15	J.-Y. Tigli	Middleware for Internet of Things, a survey on the interoperability challenge and communications patterns
Session 2		
08:00 - 10:00, 10:15 - 12:15	Laurent Gomez - SAP	LPWA networks - Tutorial LoRa
Session 3		
08:00 - 10:00, 10:15 - 12:15	G. Rocher & F. Dechavanne	IoT : MQTT - OASIS standard / Tutorial MQTT

MIT Agenda and Lecturers

Session 4		
08:00 - 10:00, 10:15 - 12:15	I. Sarray & A. Ressouche	Synchronous language for formal validation - application to CEP (complex event processing) in MQTT
Session 5		
08:00 - 10:00, 10:15 - 12:15	J.-Y. Tigli & S. Lavirotte	From IoT to WoT/WSD - Tutorial HTTP/CoAP - WS/REST - WSD
Session 6		
08:00 - 10:00, 10:15 - 12:15	S. Lavirotte & J.Y. Tigli	WSD and WSD composition in the cloud - tutorial Ubiquaria
Session 7		
08:00 - 10:00, 10:15 - 12:15	G. Rocher & F. Dechavanne	Advanced MIT : SWoT & Semantic Interoperability (G. Rocher)
Last Session	All	

Evaluation Rules :

1. Evaluation of a Practical Course : Evaluation from the Tutorial of the Modeled Complex Event Processes using Synchronous languages approaches and model checking

2. During Lecture 30/1/18 * : one or more MCQ about all the courses and tutorials before

3. Other Evaluation during lecture 20/02/18 : MCQ about all the courses and tutorials before.

4. Personal Work : Writing of a short survey paper about a technological or research topic in the field of IoT

(*) optional

▶ Dates are given for information only and may change

▶ The presence in the courses is mandatory except official justification

MCQ : Multiple Choice Questions

What about your computer and software environment for MIT Tutorials ?

For tutorials, we need :

- Linux
- Windows

Use Vmware to install them on the same machine, running the same time

Don't forget to configure :

- IP network
- Shared directory between virtual machine and your computer

Visual Studio IDE (VS Community, you can get it for free on the Web)

It's your turn …

First work … Can you write a paper ?

After reading a few survey papers,

Choose a research or technological topic to study it

An opportunity to see how to do a bibliography …

An opportunity to go ahead on the topics of this course …