

# 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



# Video

- ▶ Everytime, Everywhere, but also ... Everything
- ▶ In our everyday life
  
- ▶ Ambient Comp
- ▶ [http://www.dailymotion.com/video/xqj9gm\\_ambientcomp-integrateur-gb-hd\\_tech](http://www.dailymotion.com/video/xqj9gm_ambientcomp-integrateur-gb-hd_tech)
  
- ▶ In french ... Continuum
- ▶ [http://www.dailymotion.com/video/x2bnts6\\_continuum-version-courte\\_tech](http://www.dailymotion.com/video/x2bnts6_continuum-version-courte_tech)

# TEST your own Background

MCQ - Multiple-choice questionnaire

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See [http://www.tigli.fr/doku.php?id=cours:muc\\_2015\\_2016](http://www.tigli.fr/doku.php?id=cours:muc_2015_2016)



# IoT in a ... cloud of keywords

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

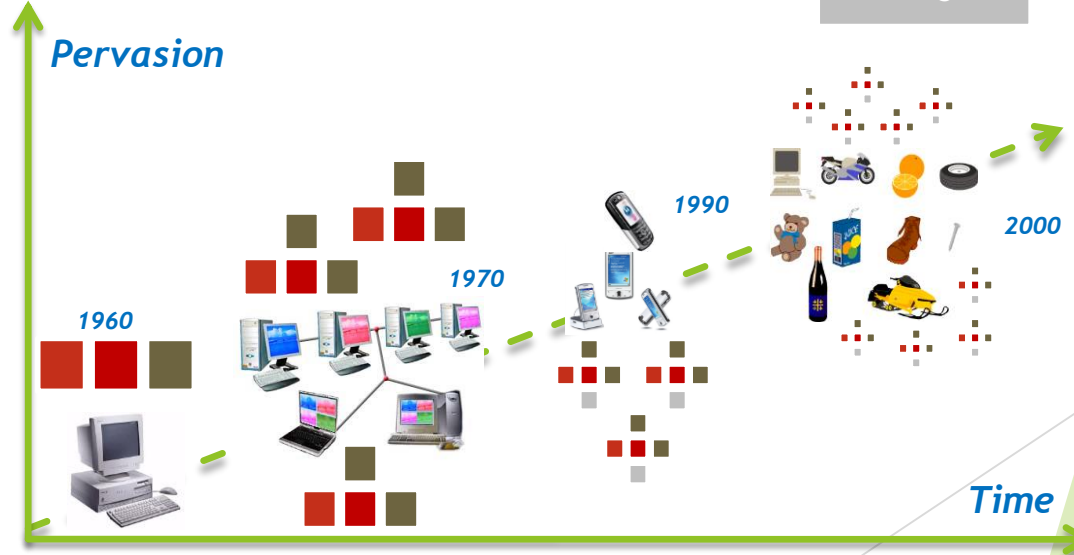


# Ubiquitous Computing (1991)

« 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 smart objects

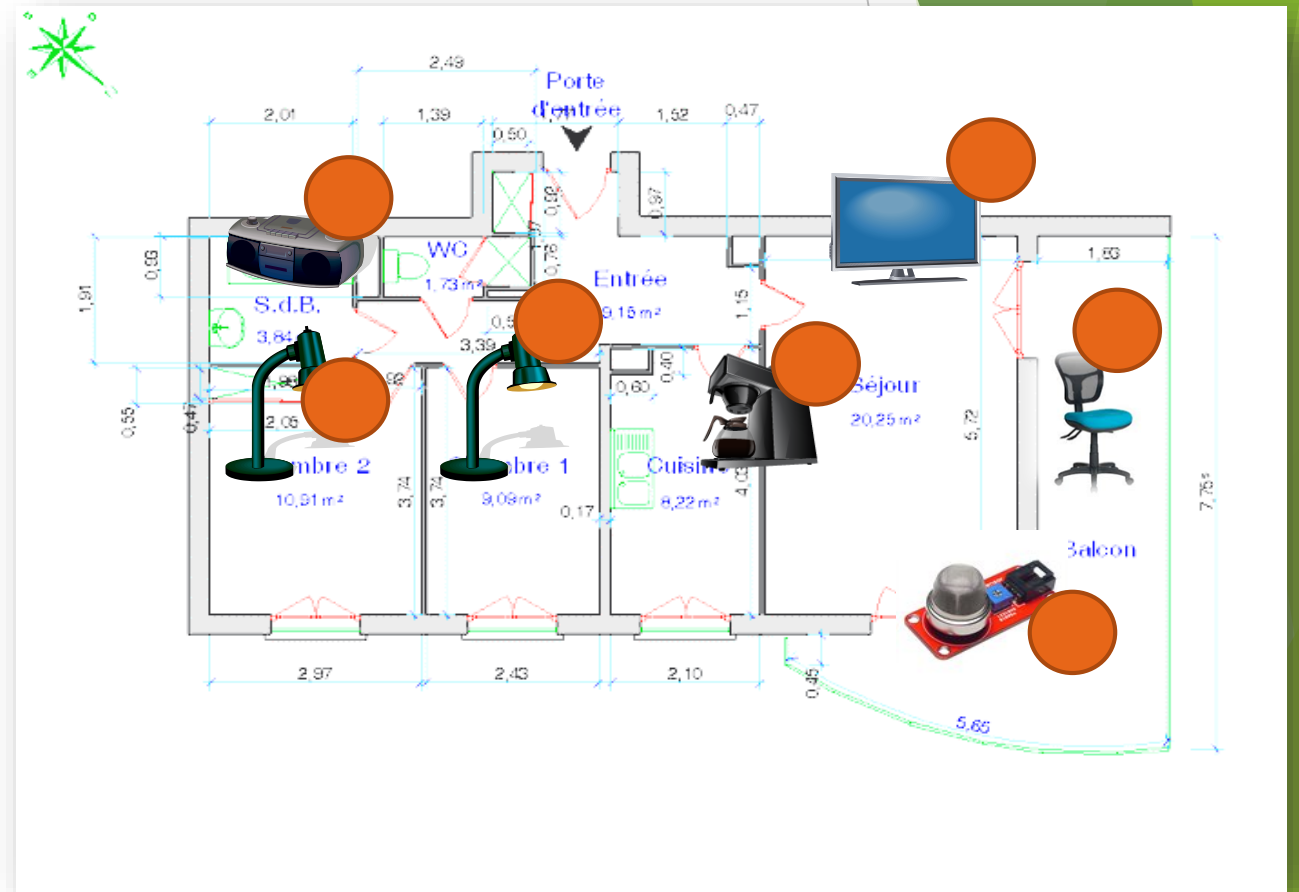
From Von Neumann Computer Model to Smart Objects ....



*Mark D. Weiser  
(chief scientist  
at Xerox PARC  
in the United  
States)  
... since 1991  
has talked  
about “the  
computer for  
the 21<sup>st</sup>  
Century”*

# CPS : Cyber-Physical System

- ▶ Since less than ten years we talk about CPS ...
- ▶ A cyber-physical system (CPS) is a system of collaborating computational elements **controlling** physical entities
- ▶ Example : **Industrial control systems** are used in industrial production for controlling equipment or machines.



Khaitan et al., "Design Techniques and Applications of Cyber Physical Systems: A Survey", IEEE Systems Journal, 2014.

# CPS (Cyberphysical Systems for physical data)

- ▶ IoT and CPS can also be viewed as :
- ▶ An Extension of Cyberspace on the physical environment
- ▶ **As the connexion of the Physical Environment with the “Cyberspace”** (“the notional environment in which communication over computer networks occurs.”)
- ▶ Main characteristic : Physical environment is a data provider
  - ▶ Well-suited for sensors network and Big Data
  - ▶ Sometimes physical data can be modified to act on the physical environment without idea of the physical process beyond.
- ▶ The model of the environment is then a Data Model
- ▶ Out of scope for data models are
  - ▶ how the sensing/actuating is achieved in the real world,
  - ▶ what kind of physical phenomena connect these data



# CPS (Cyberphysical Systems for physical process)

- ▶ IoT and CPS can also be viewed as :
- ▶ An Extension of Cybernetics principles on the physical environment
- ▶ **From Cybernetics** ("control of any system using technology")
- ▶ Main characteristic : Physical environment is a device and service provider
  - ▶ Well-suited for ambient computing
- ▶ Physical environment is a set of services on devices interacting also through physical phenomena

# Internet of Things

The background features abstract, overlapping geometric shapes in various shades of green, ranging from light lime to dark forest green. These shapes are primarily located on the right side of the slide, creating a modern, layered effect. The text 'Internet of Things' is positioned on the left side of the slide in a clean, sans-serif font.

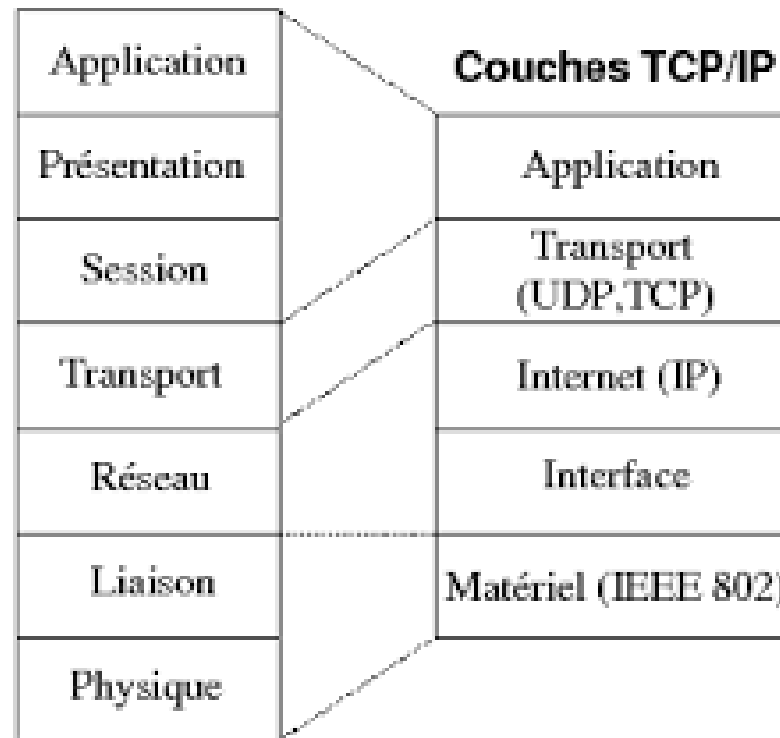
# Things are mainly based on Inputs / Outputs evolution ...

- ▶ Things is connected to Device
- ▶ Devices can be sensors
- ▶ Devices can be actuators
- ▶ Devices can be physically coupled sensors and actuators (heater : electrical resistance and temperature sensor)
- ▶ Devices can be logically coupled sensors and actuators (electrical switch and controlled light)

# Technical view of Internet of Things

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

## Couches OSI



*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>.*

# Technical limitations

- ▶ But Internet is not enough to guarantee interoperability
- ▶ This is only a common Network and Transport protocol ...
- ▶ Nothing about syntactic and lexical interoperability

**City/Infrastructure (41 Companies)**  
OPower, BRIDGE, enocean, joutex, STREETLINE, Takadu, smartbin, ECHOLON, CALM, sensinode, WaterSmart, BARON, SENSUS

**Automotive (41 Companies)**  
Zobie, Aldis, Jasper, TRAFFICAST, dash, Livemap, splitsecond, ITERIS, LOCOL MOTION, ingenie, ANAGOG

**Healthcare (100 Companies)**  
mc10, awarepoint, Watermarkmedical, Withings, DARIO, vitalconnect, Zephyr, proteus, Lively, VALEN, LUMO, Cuffbit, LARK, Sprouting, HEXOSKIN, AcherTech, intel-clinic, VALEN, REST, Rijuven, beddit

**Home (137 Companies)**  
nest, greenwave, BLINK, kisi, Lyric, SmartThings, LIFX, August, emberlight, Ayla, dropcam, entia, hello, SHUPI, wigwag, zonoff, plum, HomeMonitor, WaterSmart, notatmo, airdy, Droplet, vera, Lockitron, tado, VOCCA, CUBESENSORS, iSmartAlarm

**Fitness (92 Companies)**  
fitbit, striv, BASIS, BODYMEDIA, Heapsygn, MIFFIT, ATHOS, bia, VIGO, runastic, melo, SMART MIO, dacadoo, halo, CLOTHING+, solbi, striv, CI IARO

**Lifestyle/Entertainment (85 Companies)**  
MISELU, switto, focus, ANOVA, Narrative, Kapture, EDYN, vesityl, Loecce, DRUMPANTS, pawtrack, CEREVO

**Toys (23 Companies)**  
littleBits, Parrot, mOwayduino, LIKEMER, LightUp, Moff, sifteo, 2NERO, xyzgic, Osmo

**User Interface (36 Companies)**  
GLASS, LEAP, gestigon, metaio, mota, AVEGANT Glass, EMBRACE, LUMUS, muzzley, recon, Ring

**Platform (82 Companies)**  
electric imp, Coversant, VOLTERA, spark, relayr, BERG, machineshop, Scante, DOMOSLABS, Haltian, iotera, mawij

**Tags/Trackers (24 Companies)**  
iFind, TrackR, gecko, Gokey, tile, Trakdot, SenseGiz, duet, biki

**Smartwatch/Jewelry (43 Companies)**  
pebble, ARCHOS, FLIP, omate, hereo, neptune, LIMMEX, Emofuse, phospor, kreyos, Wellograph, SWAP, WATCH, CUFF, First Sign

**Agriculture (31 Companies)**  
BLUE RIVER, UNFARM, b, skydrop, libelium, MOBILE FARMING SYSTEMS, Vital Herd, Inc, spensa, Greenbox

**Internet of Things**  
725 Companies  
*Don't Get Out-Innovated*  
Contact [info@venturescanner.com](mailto:info@venturescanner.com)

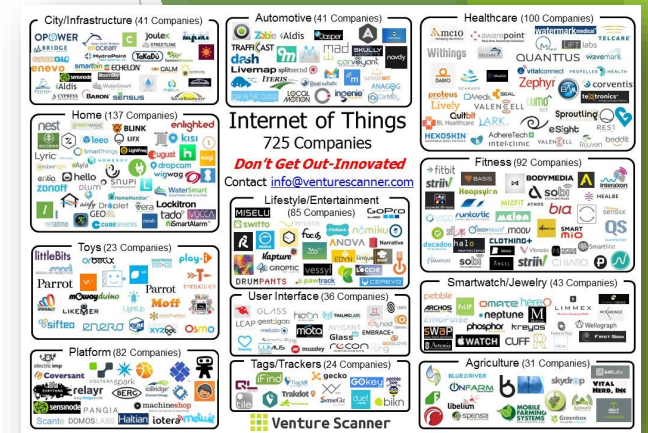
**Venture Scanner**

# 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 overcome the limitation of the specificity of API
  - ▶ How to explicitly describe the API of a Service
  - ▶ In a SOA (Service oriented Architecture) style

# Technologically : Web of Things 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 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/>*

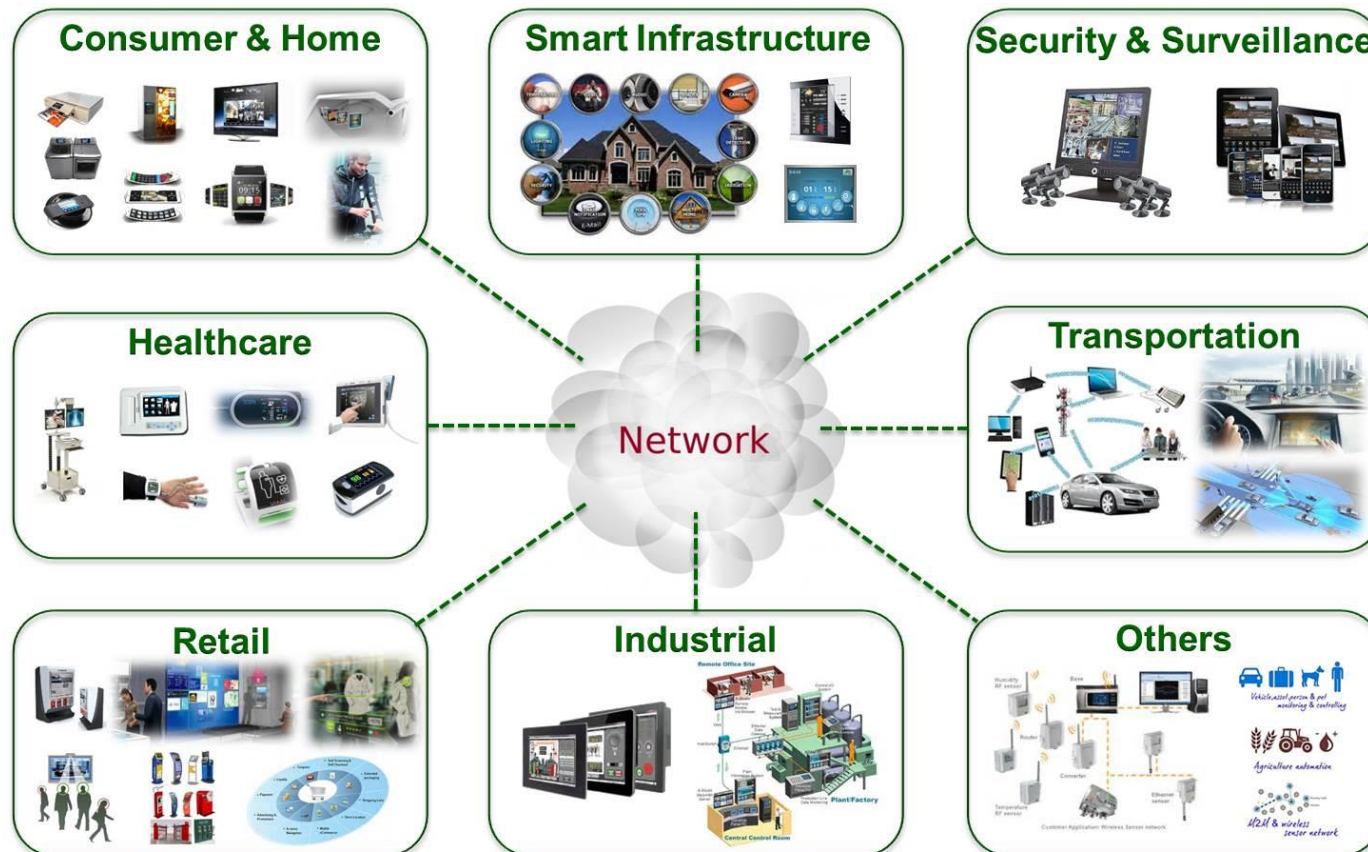
*Guinard, Dominique; Trifa, Vlad; Mattern, Friedemann; Wilde, Erik (2011). From the Internet of Things to the Web of Things: Resource Oriented Architecture and Best Practices. Springer. pp. 97-129. ISBN 978-3-642-19156-5.*



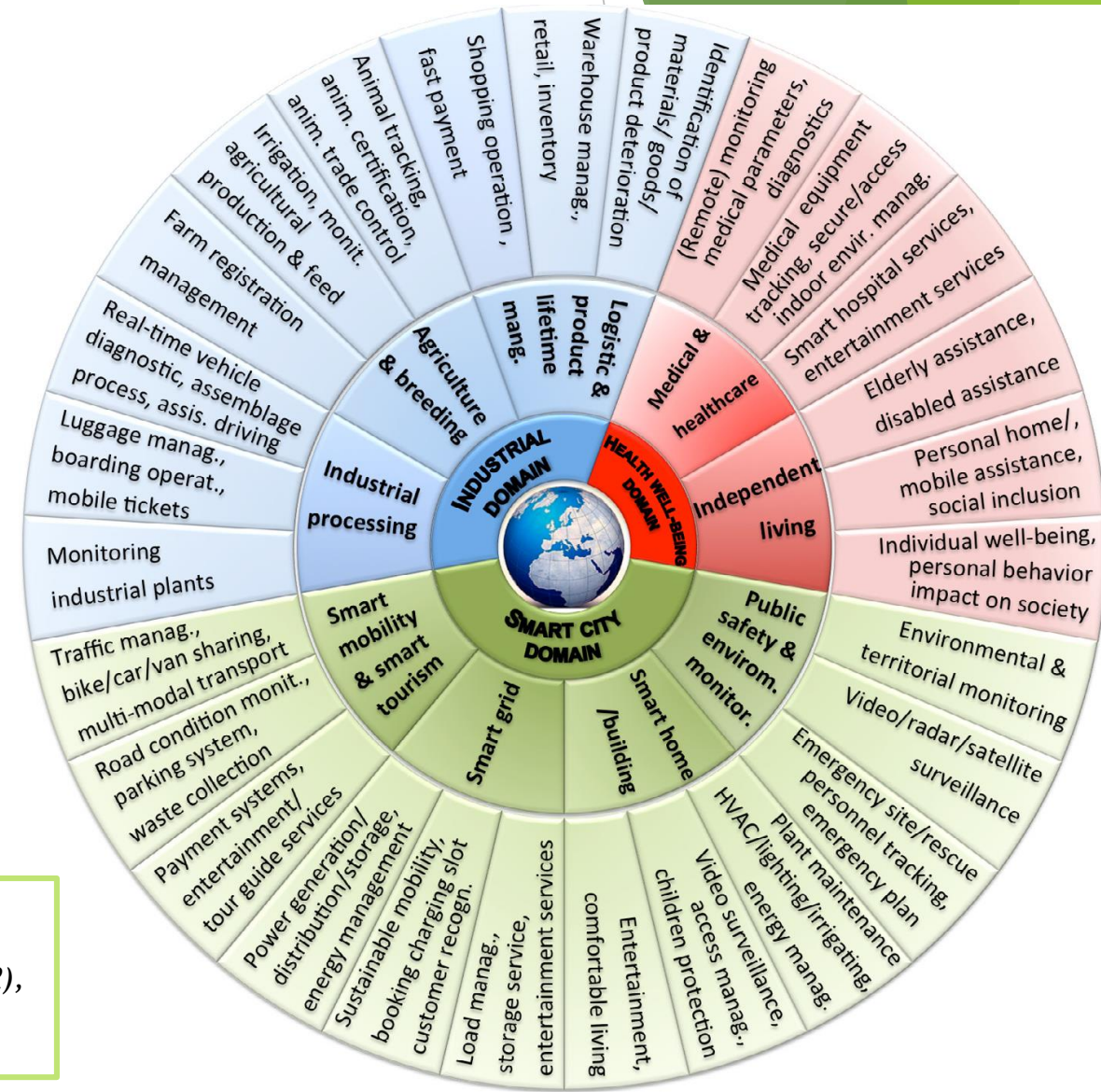
# IoT application domains

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# IoT application domains and related applications



# And more ...



*The Internet of Things vision: Key features, applications and open issues*  
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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](#)