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# Definitions of Ambient Intelligence

## 01QZP Ambient intelligence

Fulvio Corno

Politecnico di Torino, 2018/2019



<http://praxis.cs.usyd.edu.au/~peterris>



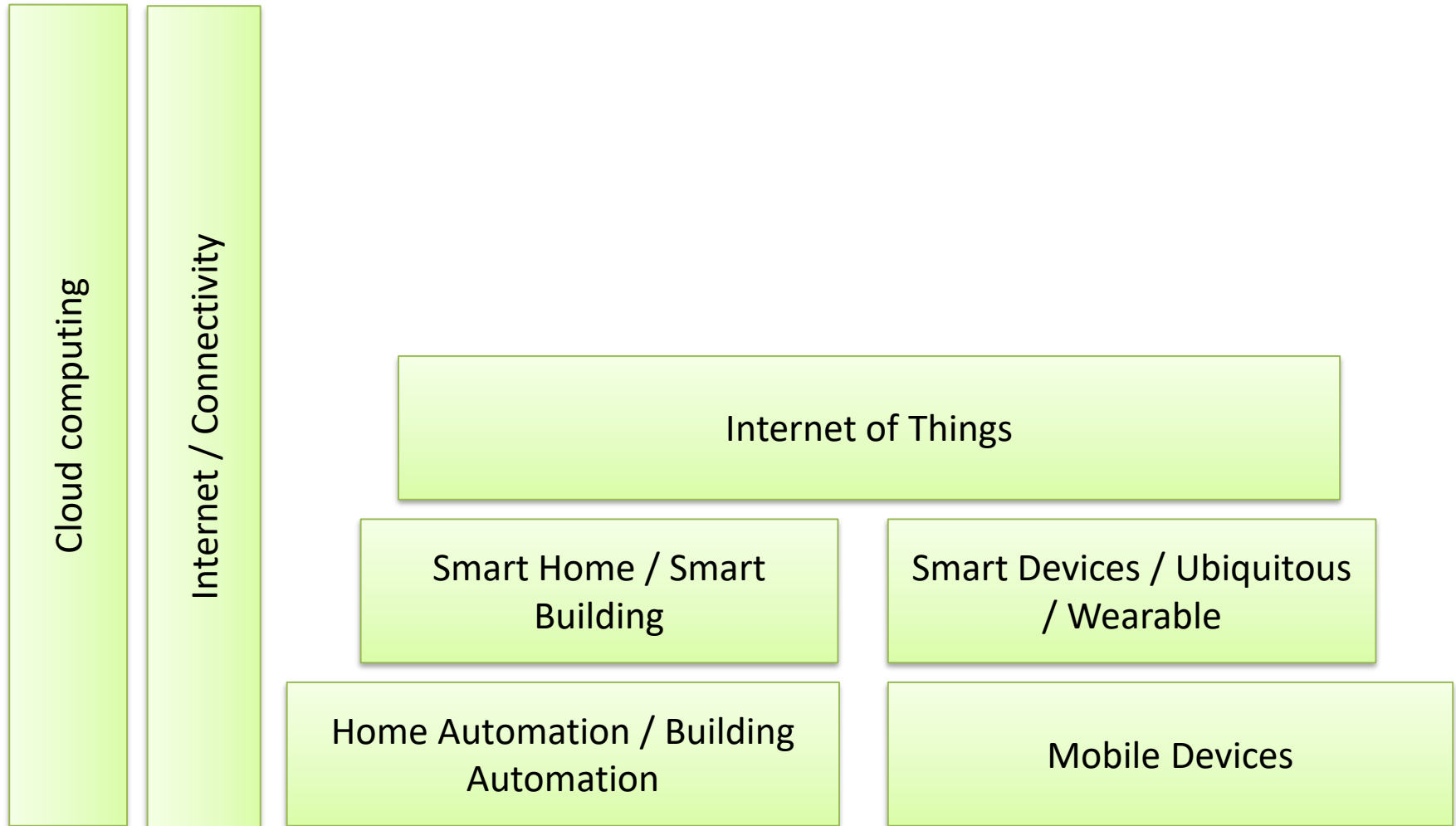
# Summary

- Technology trends
- Definition(s)
- Requested features

Definitions and Application Areas

# **TECHNOLOGY TRENDS**

# Technology trends



# Internet of Things



define iot



The **Internet of Things (IoT)** refers to the ever-growing network of physical objects that feature an IP address for internet connectivity, and the communication that occurs between these objects and other Internet-enabled devices and systems.

[What Is Internet of Things \(IoT\)? Webopedia Definition](https://www.webopedia.com/TERM/I/internet_of_things.html)  
[www.webopedia.com/TERM/I/internet\\_of\\_things.html](https://www.webopedia.com/TERM/I/internet_of_things.html)

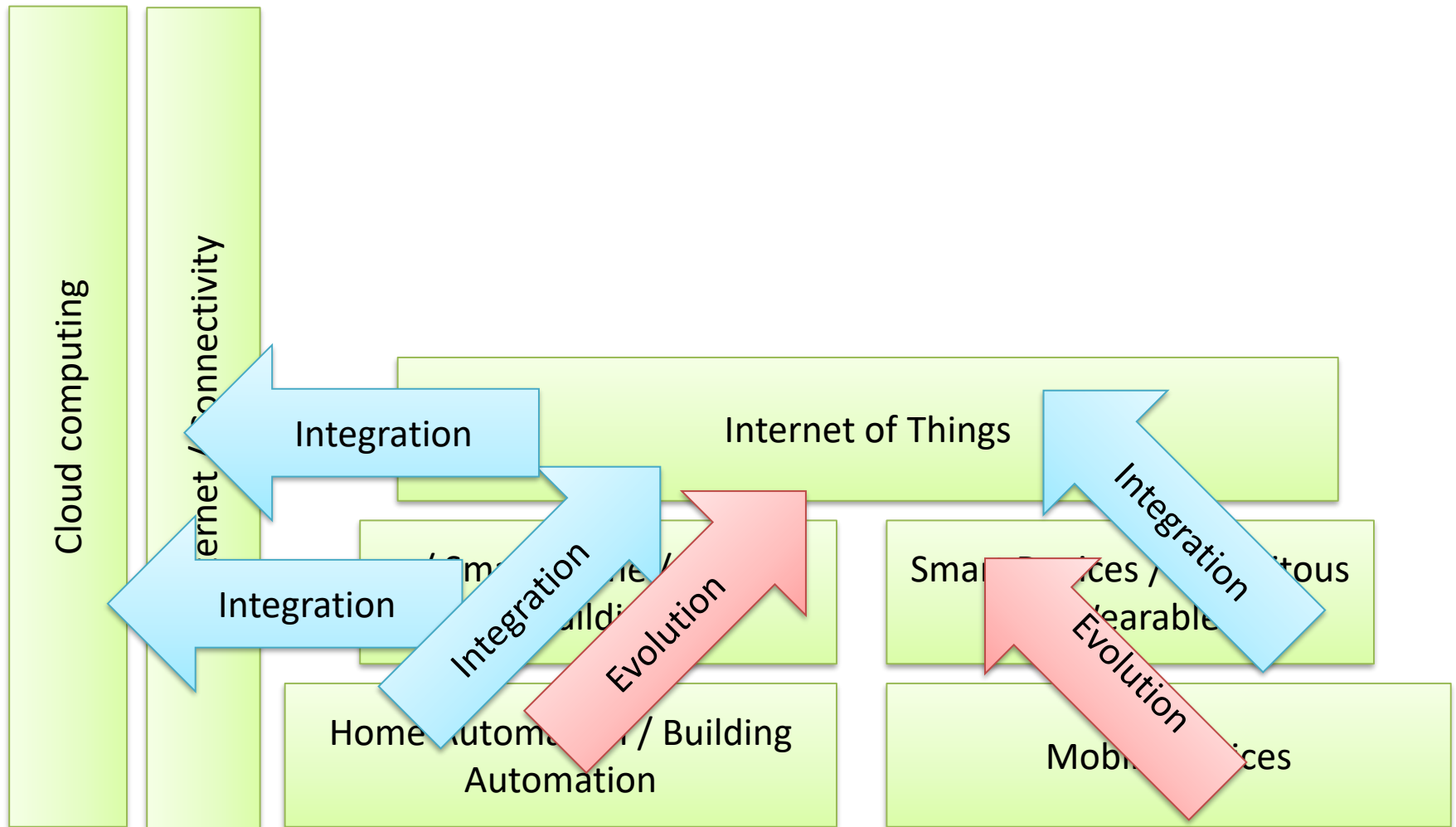
Table 1: Internet of Things (IoT) Devices Installed Base by Category

Category	2012	2014	2015	2016
Automotive	40.0	100.0	170.0	3,010.0
Consumer	1,810.0	2,214.0	2,814.0	10,370.0
Industrial Business	300.0	470.0	600.0	1,050.0
Health Business	800.0	900.0	1,000.0	1,300.0
<b>Grand Total</b>	<b>3,050.0</b>	<b>3,784.0</b>	<b>4,684.0</b>	<b>15,830.0</b>

Source: Statista (November 2016)

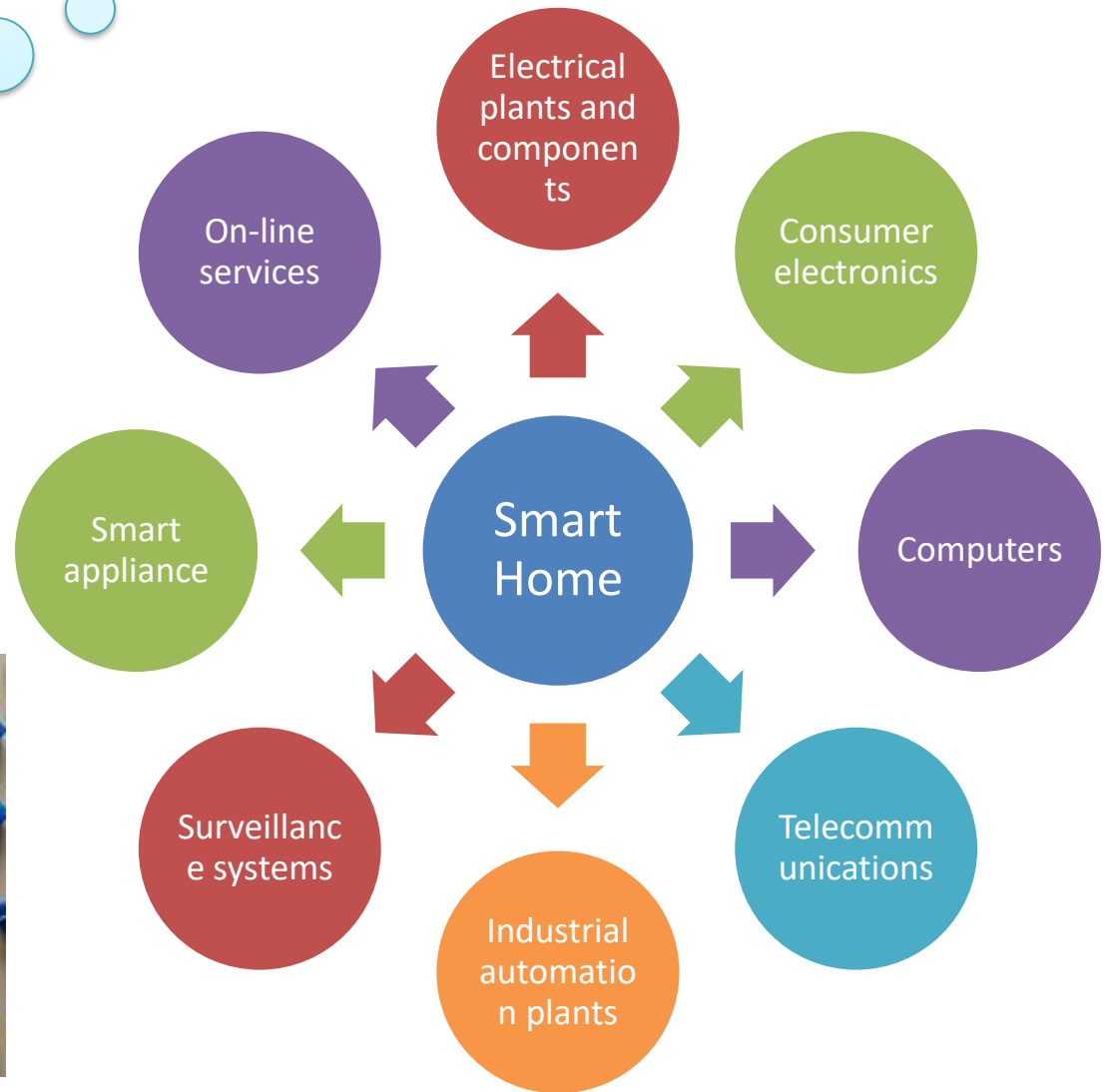
*About this result • Feedback*

# Technology trends

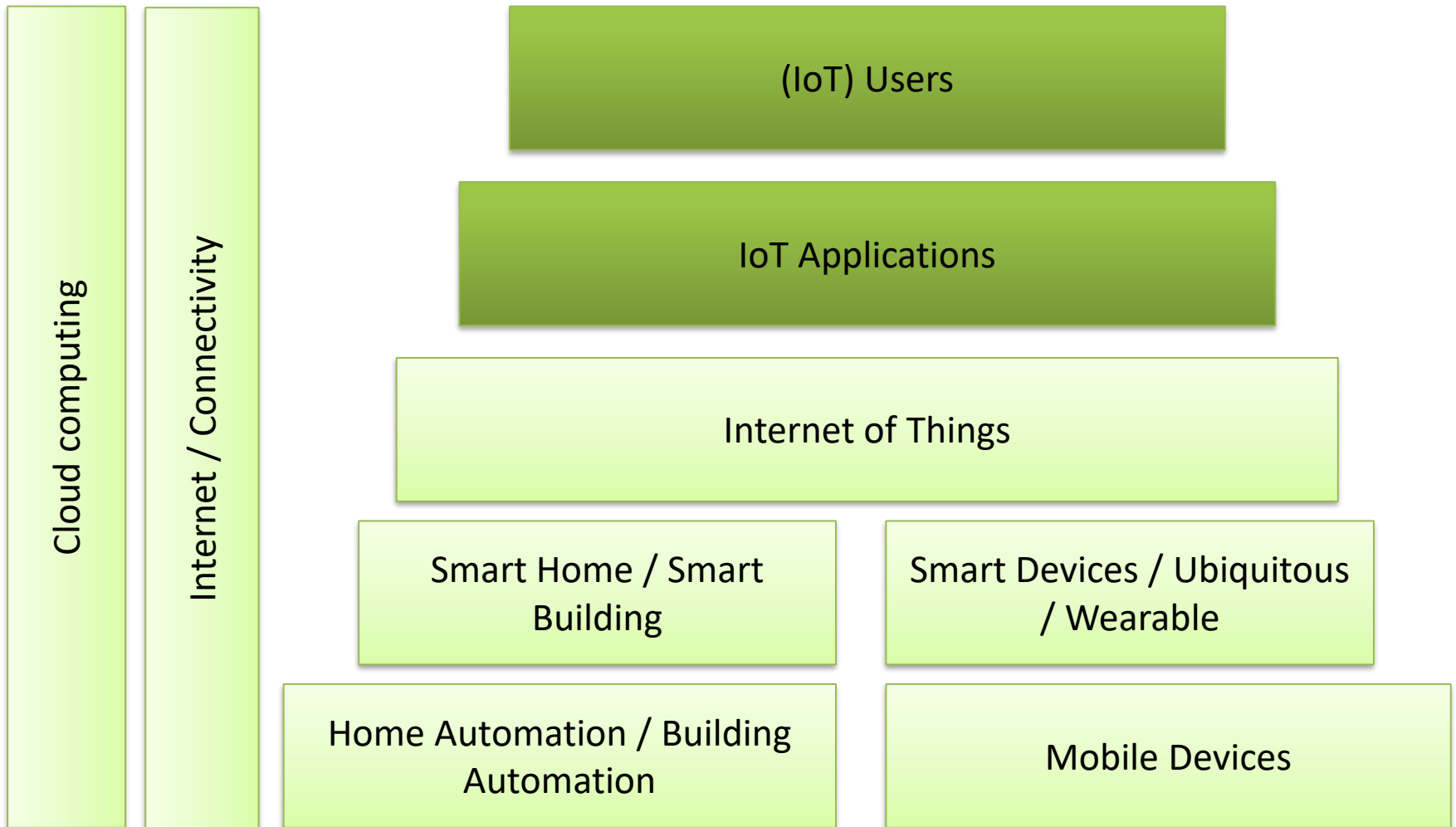


# Conquering the user

Controlling the smart home market is appealing to producers of...

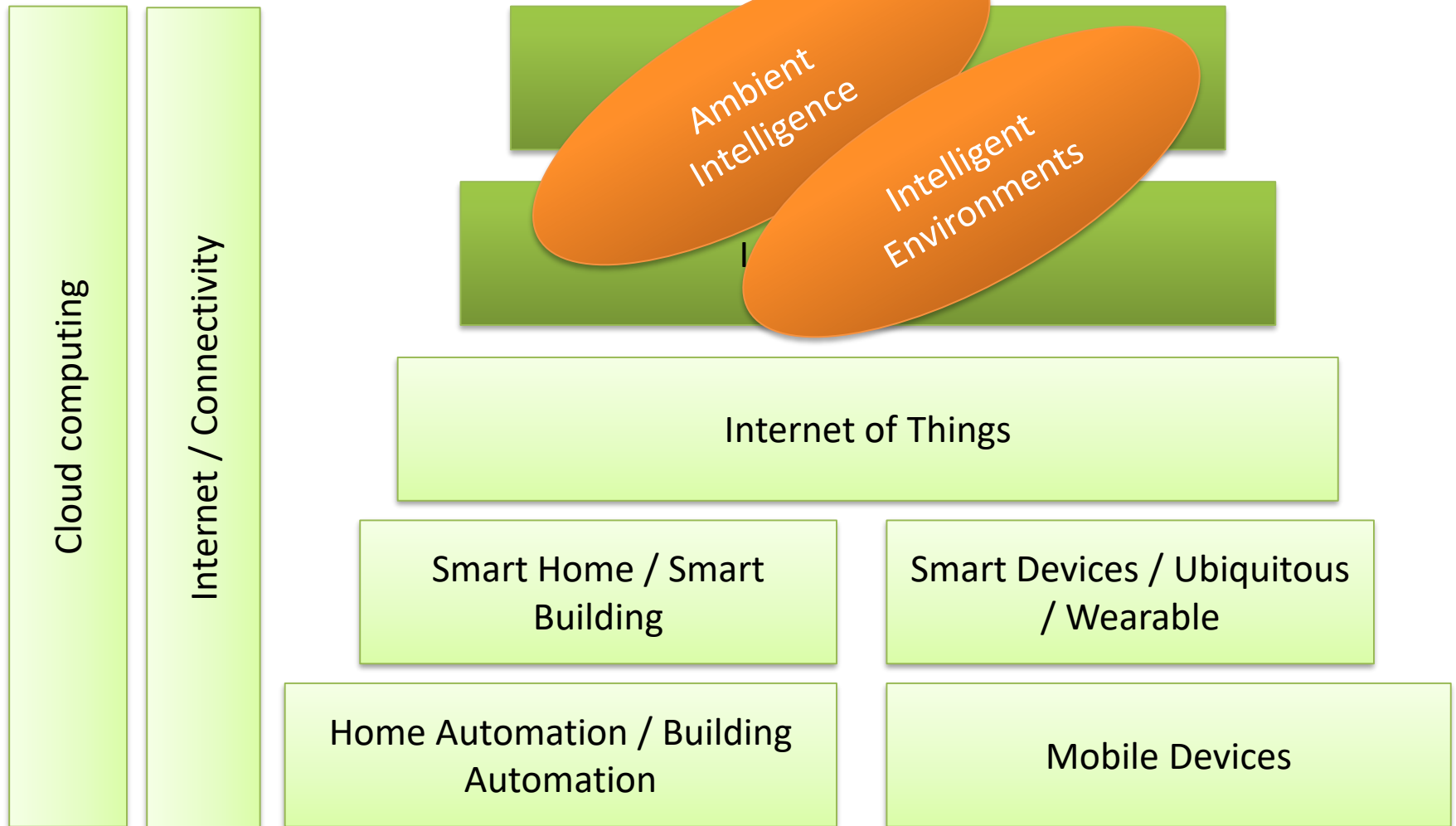


# Technology trends





# Where research is...



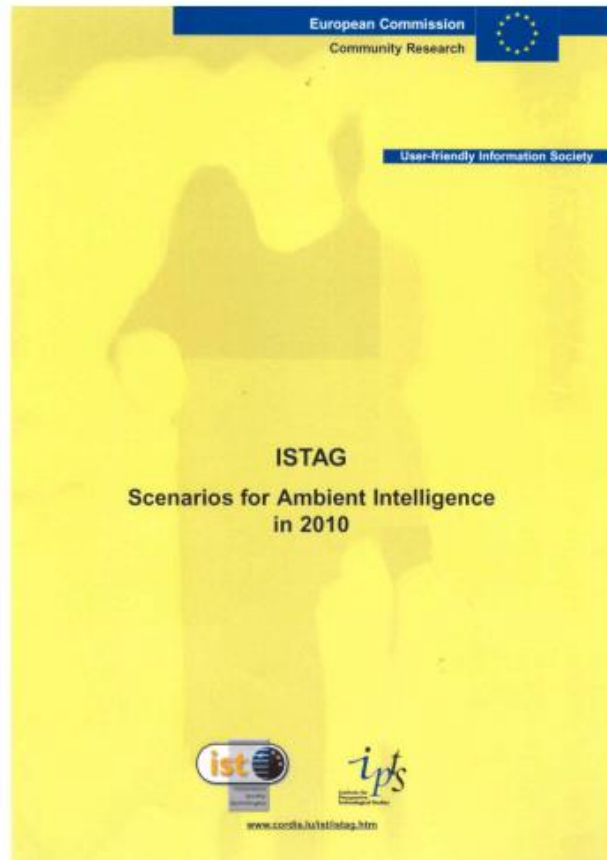
Definitions and Application Areas

# **DEFINITION(S)**

# What is Ambient Intelligence?

- Wide area
- Expectations evolving over time
- “Definition” or “prediction”?
  
- Multiple definitions found, from complementary points of view
- Some researchers trying to define a common framework

# The starting point



*Published in 2001*

- The concept of Ambient Intelligence (Aml) provides a vision of the Information Society where the emphasis is on **greater user-friendliness**, more efficient **services support**, **user-empowerment**, and support for **human interactions**. People are surrounded by **intelligent intuitive interfaces** that are embedded in all kinds of **objects** and an **environment** that is capable of **recognising** and **responding** to the presence of **different individuals** in a **seamless, unobtrusive** and often **invisible** way.

# Some other definitions

## Definition

A developing technology that will increasingly make our everyday environment sensitive and responsive to our presence [4].

A potential future in which we will be surrounded by intelligent objects and in which the environment will recognize the presence of persons and will respond to it in an undetectable manner [1].

“Ambient Intelligence” implies intelligence that is all around us [5].

The presence of a digital environment that is sensitive, adaptive, and responsive to the presence of people [6].

A vision of future daily life ...contains the assumption that intelligent technology should disappear into our environment to bring humans an easy and entertaining life [7].

A new research area for distributed, non-intrusive, and intelligent software systems [8]

In an Aml environment people are surrounded with networks of embedded intelligent devices that can sense their state, anticipate, and perhaps adapt to their needs [9].

A digital environment that supports people in their daily lives in a nonintrusive way (Raffler) [10].

# Ambient Intelligence (Aml)

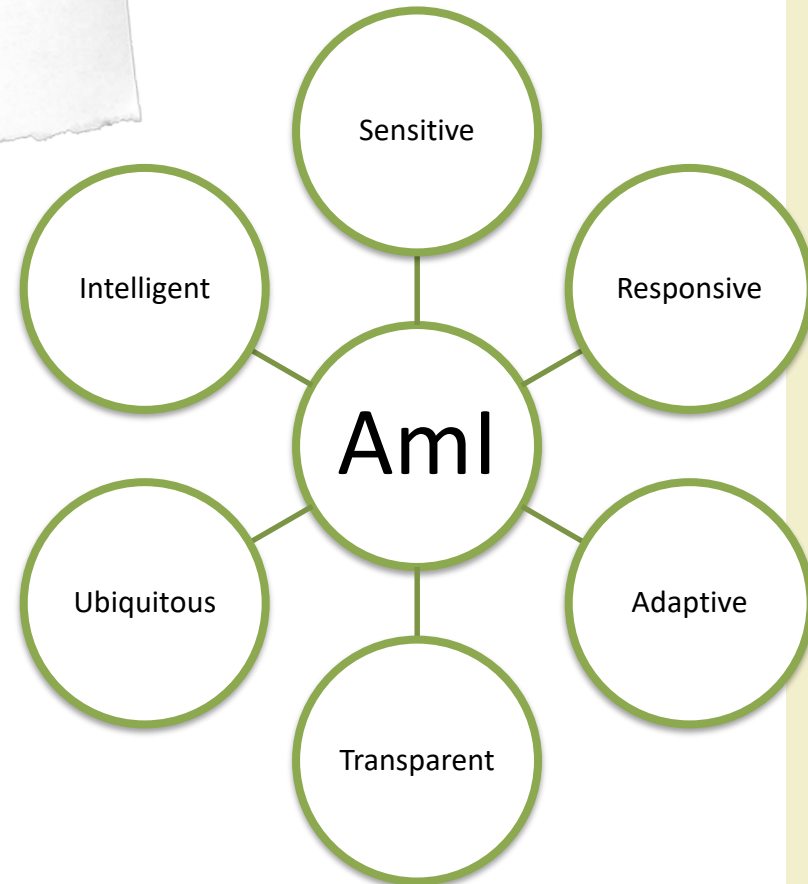
An Ambient Intelligence system is a **digital environment** that **proactively, but sensibly, supports people in their daily lives.**

(Cook et al, Ambient Intelligence: Technologies, applications and opportunities, 2009)

*why*

*what*

*Aml is  
people-  
oriented*



# Comprehensive IE definition

- “An **Intelligent Environment** is one in which the actions of numerous networked controllers (controlling different aspects of an environment) is orchestrated by self-programming pre-emptive processes (e.g., intelligent software agents) in such a way to create an interactive holistic functionality that **enhances occupants experiences.**”

Augusto et al, Intelligent Environments: a Manifesto, 2013

# Mandatory Reading

Augusto et al. *Human-centric Computing and Information Sciences* 2013, **3**:12  
<http://www.hcis-journal.com/content/3/1/12>

Human-centric Computing  
and Information Sciences  
a SpringerOpen Journal

RESEARCH Open Access

## "Intelligent Environments: a manifesto"

Juan C. Augusto<sup>1\*</sup>, Vic Callaghan<sup>2</sup>, Diane Cook<sup>3</sup>, Achilles Kameas<sup>4</sup> and Ichiro Satoh<sup>5</sup>

\* Correspondence:  
jaugusto@mdx.ac.uk  
<sup>1</sup>Middlesex University, London, UK  
Full list of author information is  
available at the end of the article

**Abstract**  
We explain basic features of an emerging area called Intelligent Environments. We give a short overview on how it has developed, what is the current state of the art and what are the challenges laying ahead. The aim of the article is to make aware the Computer Science community of this new development, the differences with previous dominant paradigms and the opportunities that this area offers to the scientific community and society.

**Basic concepts**  
Here we explain how the area of *Intelligent Environments* (IE) has developed, what its core values are and how it differs from other areas. By "Environment" we refer here to any space in our surroundings. Although some people may also consider virtual environments here we mostly refer to Physical spaces, in all its diversity, e.g., house, building, street, a field, an area in the sea or space, etc. Our use of the word "Intelligent" applied to Environments mostly refers to Artificial Intelligence, as defined in [1]. An *Intelligent Environment* is one in which the actions of numerous networked controllers (controlling different aspects of an environment) is orchestrated by self-programming pre-emptive processes (e.g., intelligent software agents) in such a way as to create an interactive holistic functionality that enhances occupants experiences.

**Historical development of the area**  
For centuries humans have witnessed scientific and technological leaps that changed the lives of their generation, and those to come, forever. We are no exception. In fact many of those advances are occurring now, in a more or less unperceivable way. Slowly and silently technology is becoming interwoven in our lives in the form of a variety of devices which are starting to be used by people of all ages and as part of their daily routine. As predicted by M. Weiser [2], this technology is gradually disappearing from our cognitive front, as we increasingly take for granted its existence. But this fact alone could not justify a paradigm shift, as we claim in this manifesto.

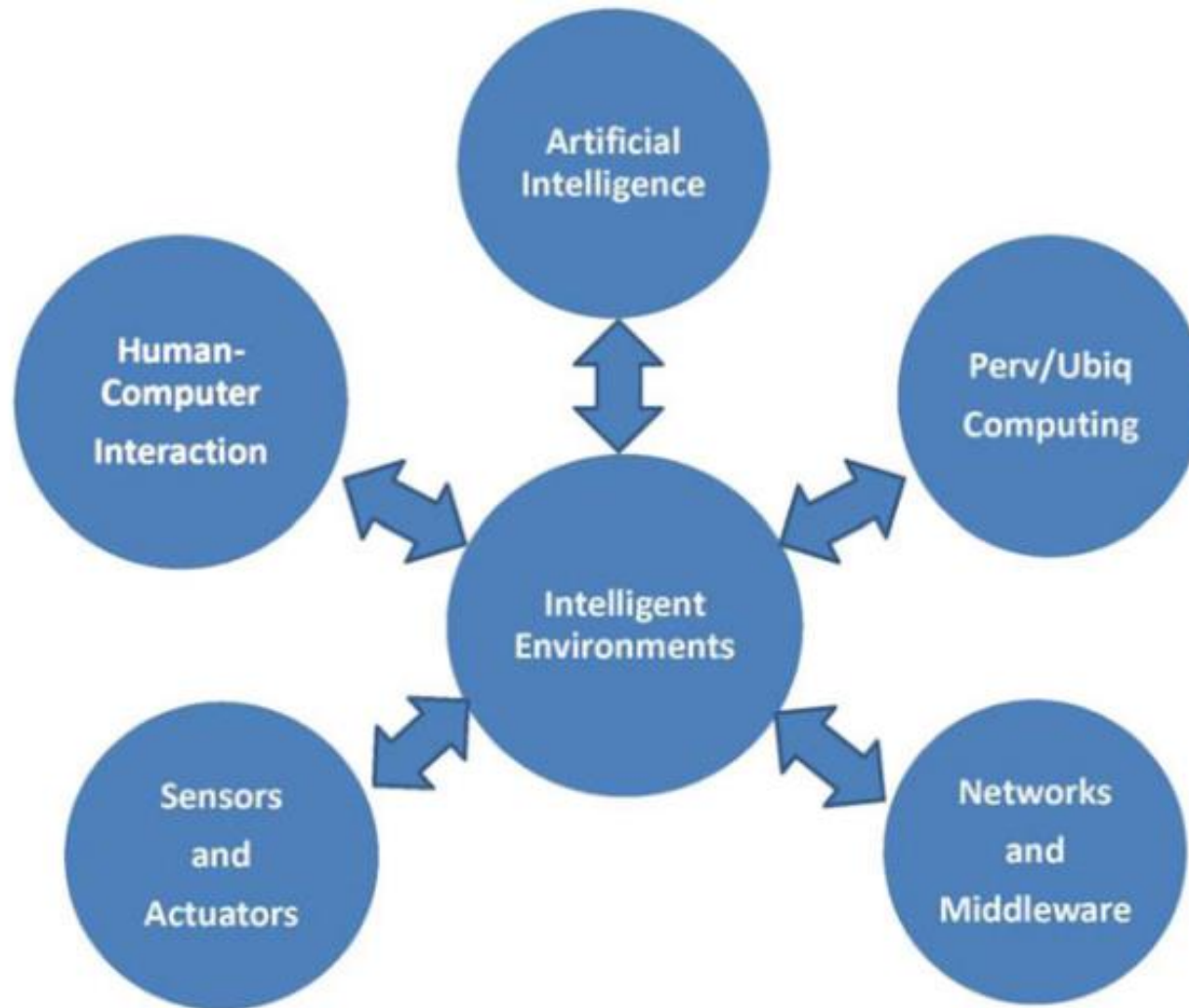
The emergence of a new paradigm requires the convergence of various domains of human activity, many of which are not technological. It is true that numerous technological advances have taken place during the past two decades worldwide, mainly due to persistent efforts by researchers and systematic funding by governments and markets. Among these advances one could site:

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 Springer

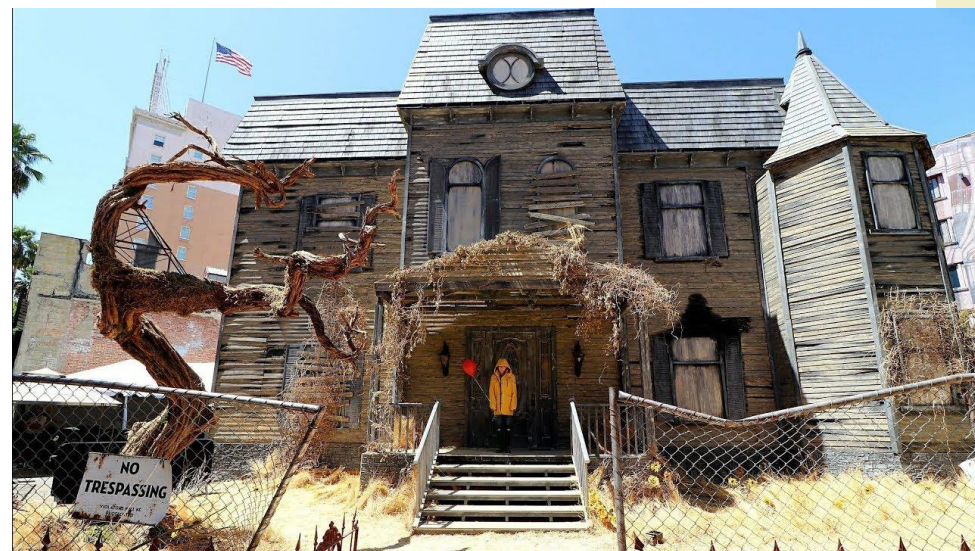


# Interactions among disciplines



# Quiz

- What is the difference: enchanted house - haunted house?



# Quiz

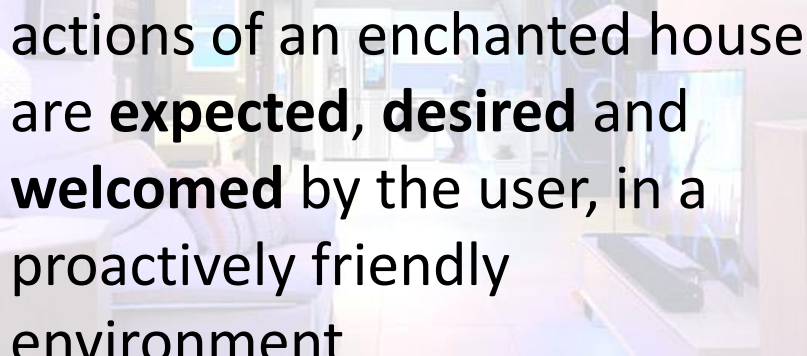
- What is the difference: enchanted house - haunted house?

- Both are **autonomous** in performing some **actions**
  - playing music
  - controlling doors and windows
  - providing food and entertainment,
- Both could be powered by similar **intelligent systems**

# Quiz

- What is the difference: enchanted house - haunted house?

- Difference lies in **user perception**

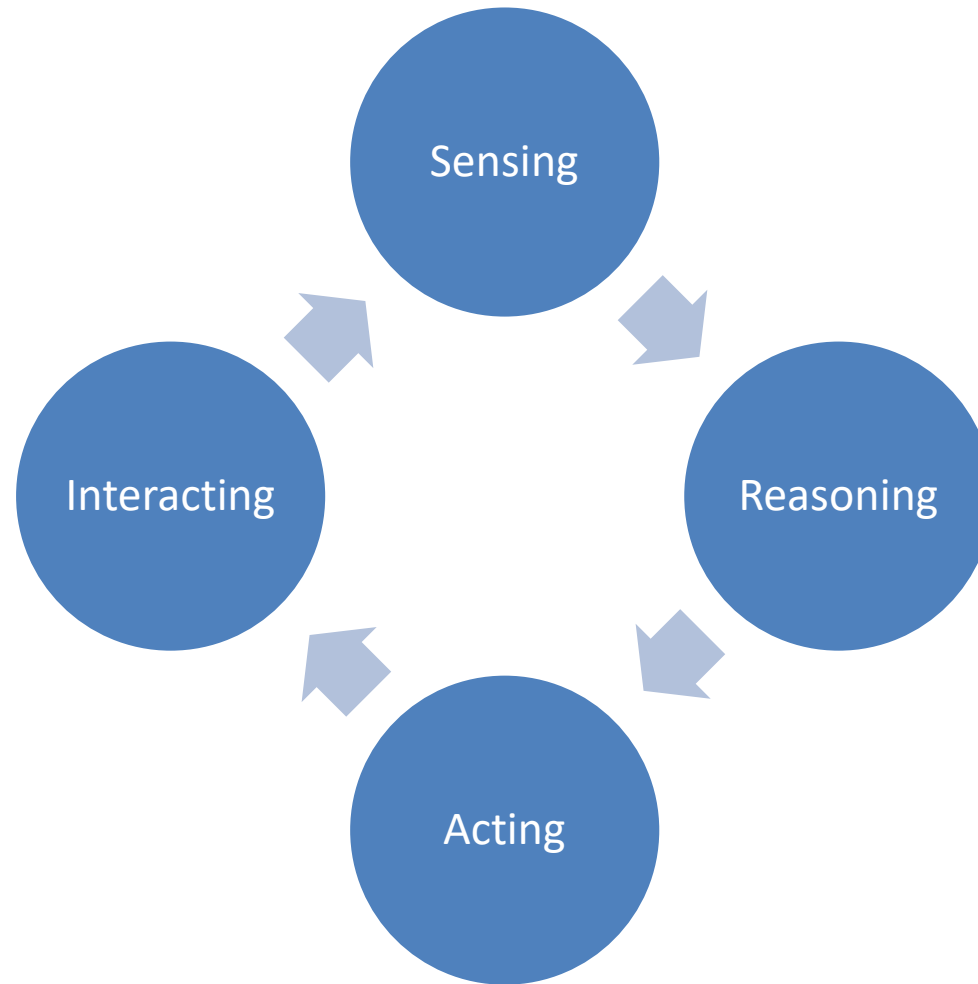


actions of an enchanted house are **expected, desired** and **welcomed** by the user, in a proactively friendly environment

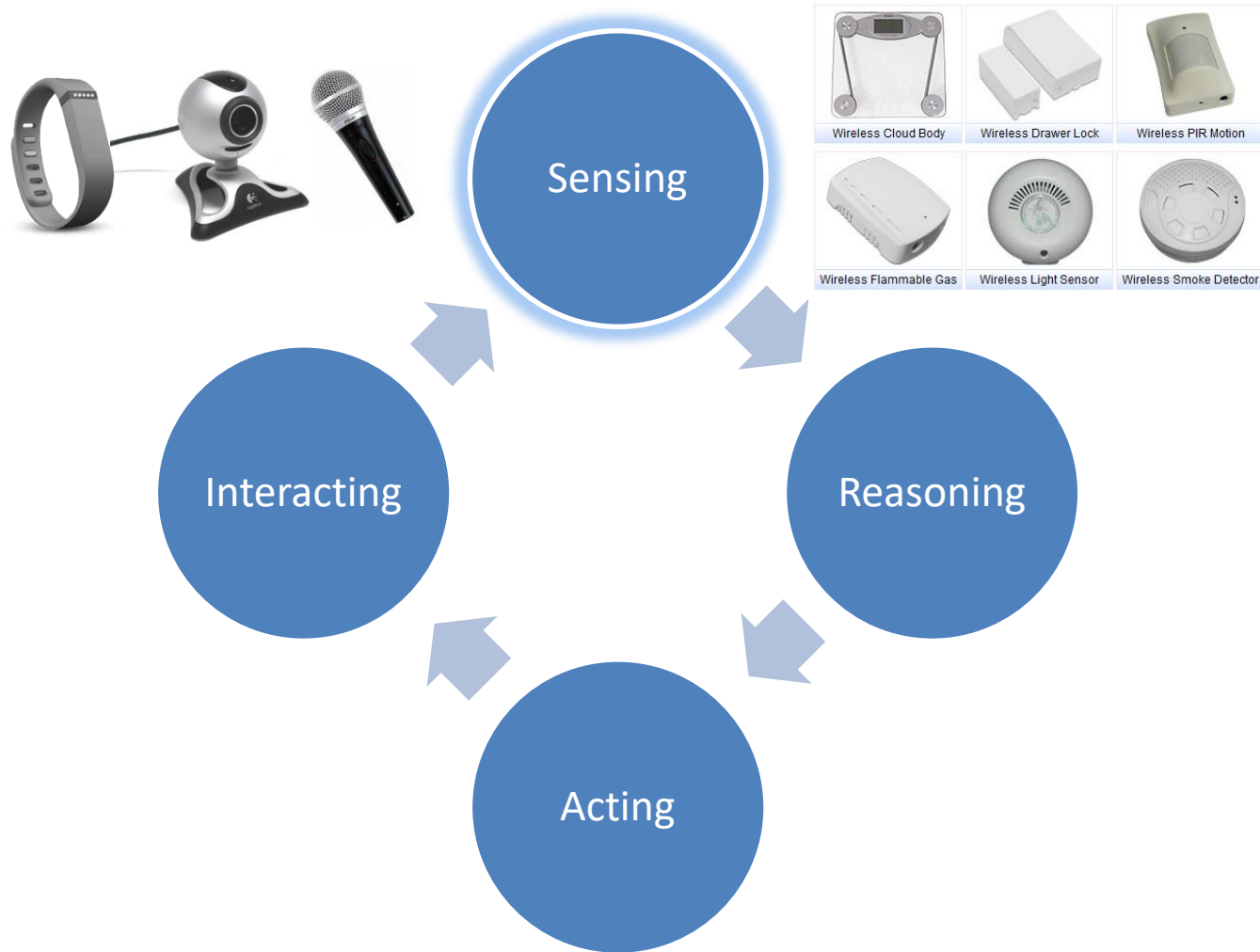


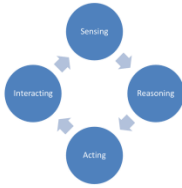
the haunted space will execute actions **contrary** to the will of the user, who will feel **trapped** by an **hostile** entity

# Main steps for Aml



# Main steps for Aml





# Sensing

- Sensors, sensor networks
  - Wired or wireless
  - Independent or embedded in a device (eg. Smartphone)
- Ambient or body

Sensing type	Common uses
Strain and pressure	Floors, doors, beds, sofas, scales
Position, direction, distance and motion	Security, locator, tracking, falls detection
Light, radiation and temperature	Security, location, tracking, health safety, energy efficiency
Solids, liquids and gases	Security and health, monitoring, pool maintenance, sprinkler efficiency
iButton	Used to identify people and objects
Sound	Security, volume control, speech recognition
Image	Security, identification, context understanding

# Examples (ambient, wireless)





# Examples (wearable)



Metria™ Informed Health  
3-axis accelerometer, Galvanic Skin Response,  
2 temperature sensors (body, skin)



Self-tracking  
Steps, calories, sleep, distance, ...



<http://www.notchdevice.com/>  
Inside clothes  
Haptic Feedback  
Movement capture



**emotive**  
you think, therefore, you can



# Sensor data

Huge

Noisy

Missing points

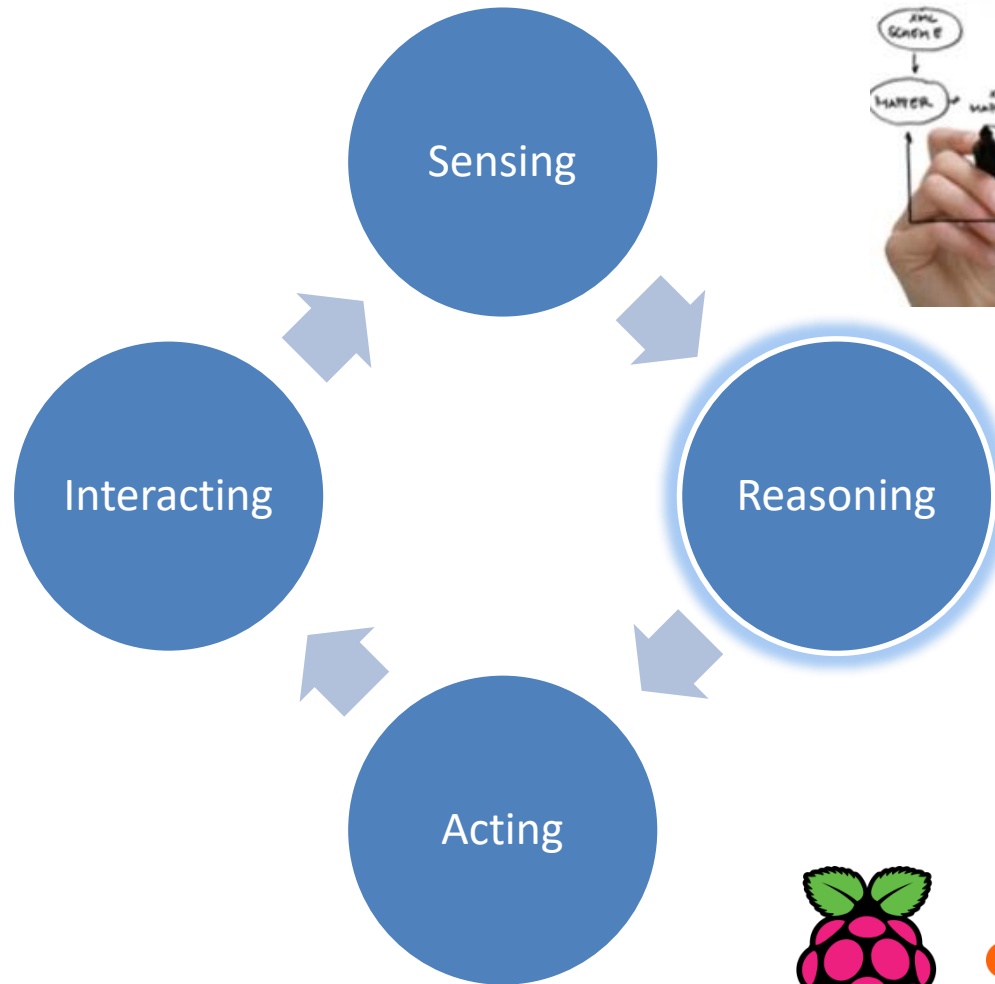
Heterogeneous  
measures

Time- & space-  
dependent

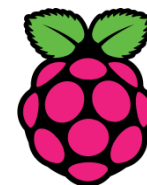
Raw vs.  
processed

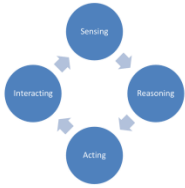
- “Making sense of data”
- Stream data processing
- Signal processing algorithms
- Sensor fusion
- Big data handling
- Filtering, disambiguation, interpretation

# Main steps for Aml



{JSON}

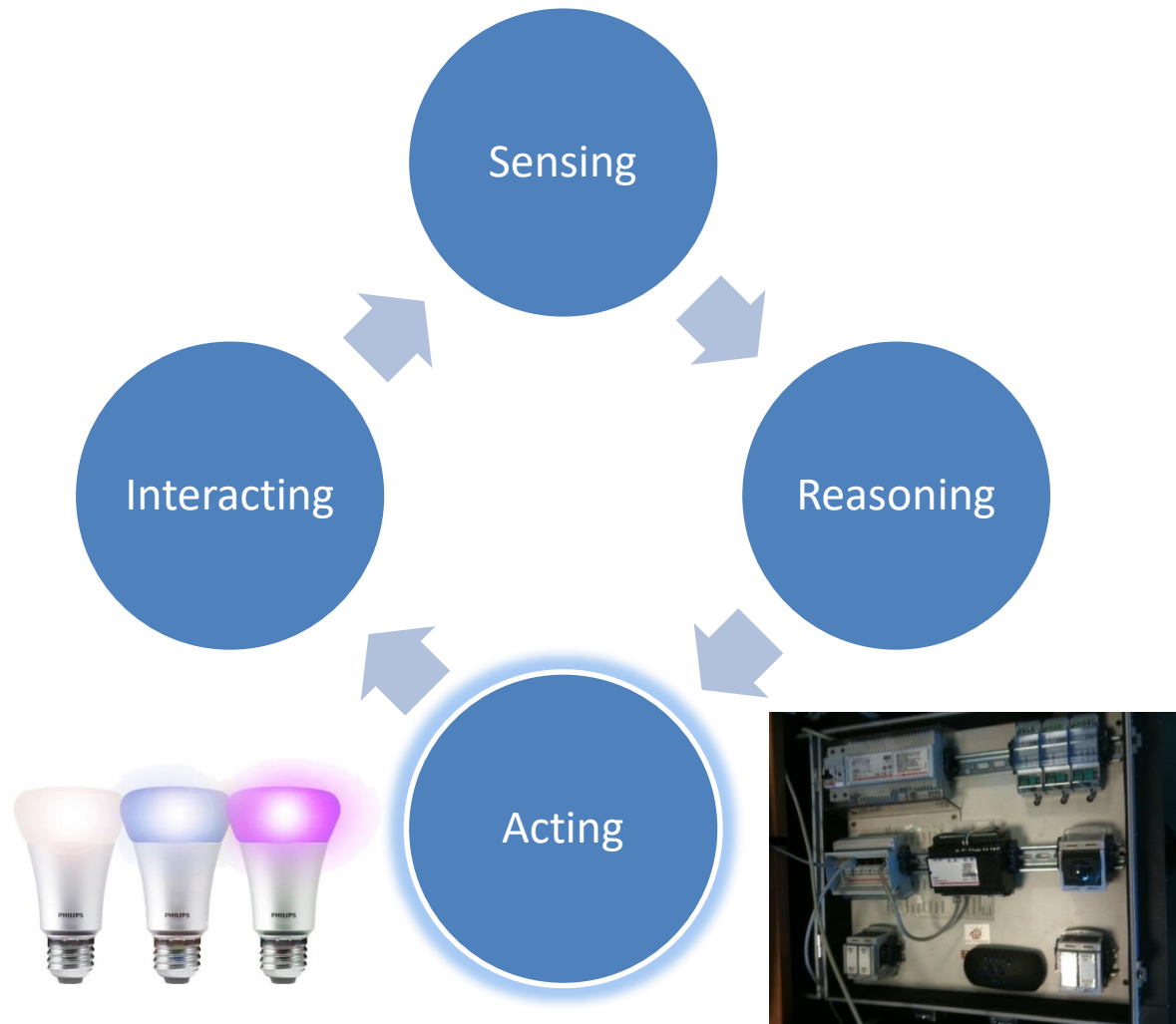


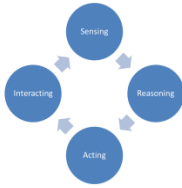


# Reasoning

- Needed to provide responsiveness and adaptability
- Interpret and recognize context and activity
- User modeling, context modeling
- Context detection and context awareness
- Mobility tracking
- Activity recognition, activity prediction
- Decision making
  - Acting vs. suggesting
- Centralized vs. Distributed

# Main steps for Aml





# Acting

- Home automation systems (lights, doors, windows, temperature, ...)
- User Interfaces or Wearable devices (notifications, information, alerting, ...)
- Robots



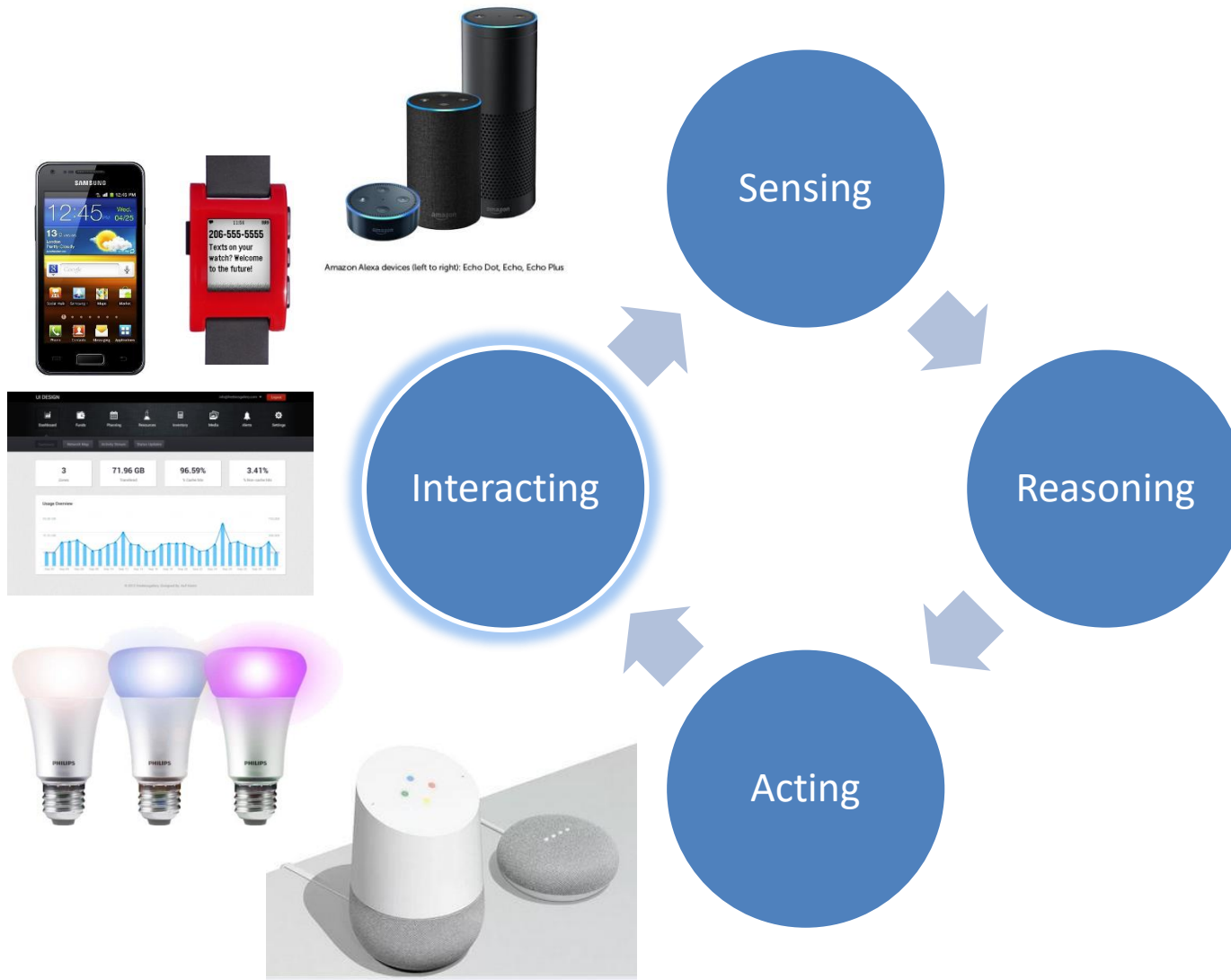
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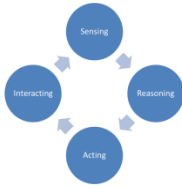


Ambient intelligence

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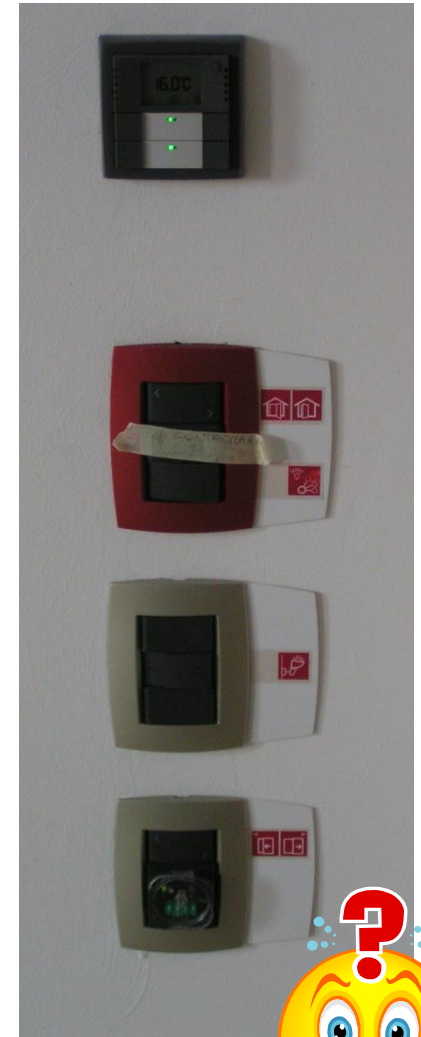
# Main steps for Aml





# Interacting with users

- Traditional user interfaces
  - Web, mobile
- Home fixtures
- Natural user interfaces
  - Speech, gestures, body motion tracking, emotions, facial expressions, attention, ...
  - Interaction bypasses ICT equipment (“disappearing computer”)
- **Should be** the most important aspect of an Aml, but...





# Don't push technologies



## #IoT: The Internet of Things and Humans

The IoT requires thinking about how humans and things cooperate differently when things get smarter.

by Tim O'Reilly | @timoreilly | +Tim O'Reilly | Comments: 9 | April 16, 2014

<http://radar.oreilly.com/2014/04/iOTH-the-internet-of-things-and-humans.html>



## Most of what we need for smart cities already exists

Culture, play, and an emphasis on fair use will help smart cities take root.

by Glen Martin | @GlenWM5440 | +Glen Martin | Comments: 1 | May 1, 2014

<http://radar.oreilly.com/2014/05/most-of-what-we-need-for-smart-cities-already-exists.html>

# Application areas

- The general principles are applicable to different types of environments
  - Private homes
  - Public/shared buildings
  - Open spaces
- The type of applications is extremely varied
- The approach and many founding technologies are shared across application domains

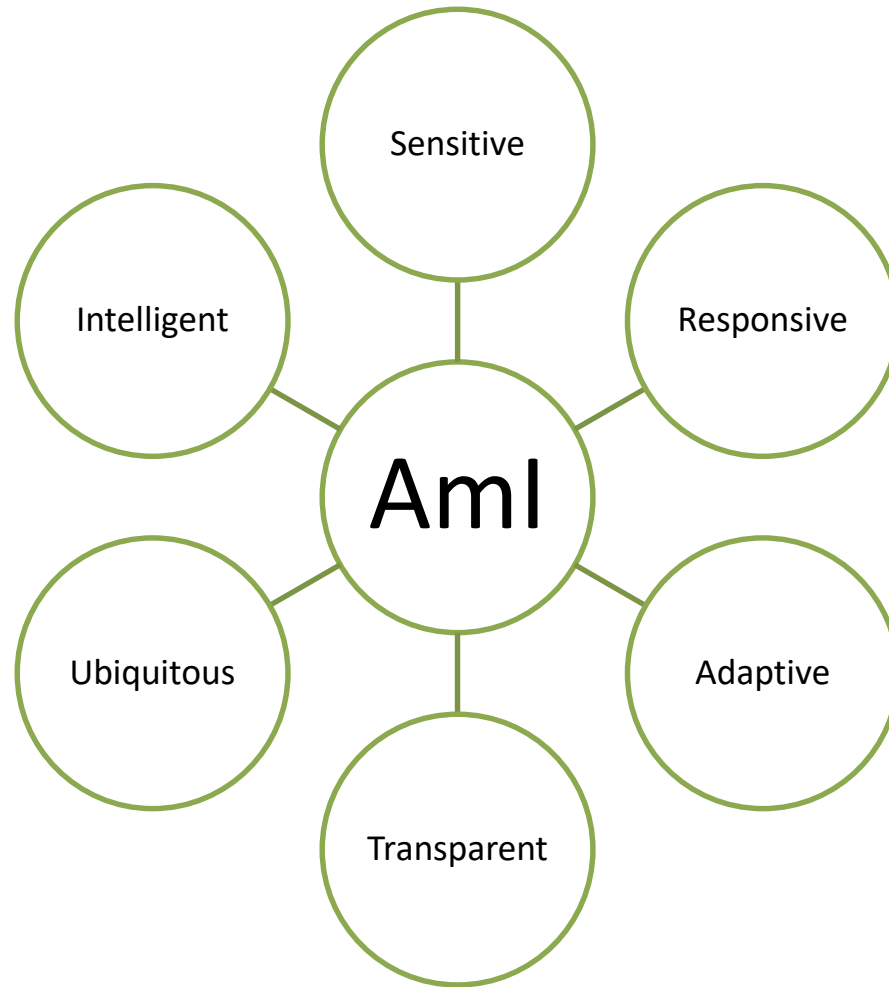
Definitions and Application Areas

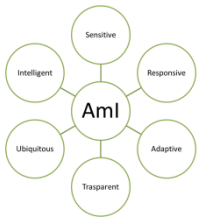
# **REQUESTED FEATURES**

# Features

- What are the features characterizing an Aml system?
- What is really an “intelligent” system, versus a “smart” one, versus an “automated” one?
- What characteristics are implied by the Aml definition(s)?

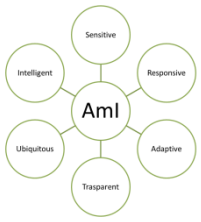
# Features





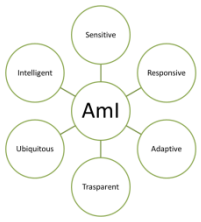
# Sensitive & Responsive

- Able to sense
  - The environment
  - The occupants
- Able to process sensor data
- Able to respond to user needs
- Able to act on the environment



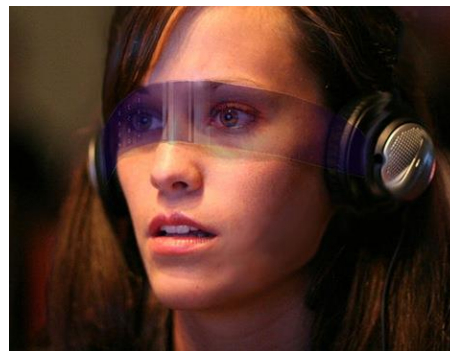
# Adaptive

- Able to infer a situational context
  - From environment data
  - From user data (identity, presence, actions, ...)
  - From statistics and preferences
  - From external information sources
- Able to adapt to the context
  - the interpretation of sensing
  - the generated response
- «Context-Aware Computing»

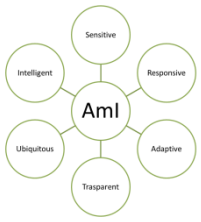


# Transparent

- «The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it» (Weiser, 1991)
- «Disappearing computer»

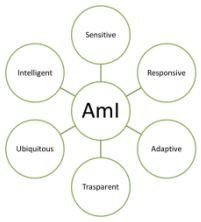






# Ubiquitous

- Ubiquitous Computing, Pervasive Computing
  - Ubiquitous: present, appearing, found everywhere
  - Pervasive: spreading widely throughout an area or a group of people
- Able to be distributed over the ambient and over different people
- Requires mobility, miniaturization, wireless communications, energy management
- Requires interoperability, discovery, self-configuration



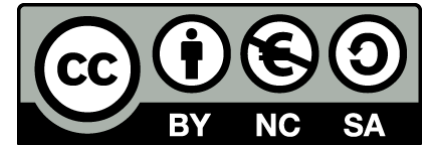
# Intelligent

- Incorporates Artificial Intelligence:
  - Machine learning, agent-based software, robotics
  - Hearing, vision, language, knowledge processing
  - Semantic web, reasoning
- AI is an enabler for achieving context awareness, adaptivity, proactive responsiveness

# Resources

- Scenarios for Ambient Intelligent in 2010, ISTAG Group, 2001
- Smart Environments: Technology, Protocols and Applications, DJ Cook, S Das, John Wiley & Sons, 2004
- How smart are our environments? An updated look at the state of the art, DJ Cook, SK Das - Pervasive and mobile computing, 2007
- Ambient intelligence: Technologies, applications, and opportunities, DJ Cook, JC Augusto, VR Jakkula - Pervasive and Mobile Computing, 2009
- Intelligent environments: a manifesto, JC Augusto, V Callaghan, D Cook, A Kameas, I Satoh - Human-centric Computing and Information Sciences, 2013
- Ambient Intelligence: A Survey, F Sadri, ACM Comput. Surv., October 2011

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