

1. The Internet of Things

Computational Intelligence for the Internet of Things (2019-20)

João Paulo Carvalho

joao.carvalho@inesc-id.pt

INESC-ID
Instituto Superior Técnico, Universidade de Lisboa



inesc-id.pt



The Internet of Things (IoT)

- What is the IoT?
- History
- What drives the IoT?
- Overview
- Enabling technologies
- Intelligence in the IoT
- Applications
- Challenges

What is the IoT?

- Internet of Things:
 - “A system of interrelated computing devices, mechanical and digital machines, objects and living beings that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction”
 - Em Português corrente: “Um conjunto de coisas, identificadas de forma unívoca, automaticamente interligadas através da Internet!”
- Exemplos:





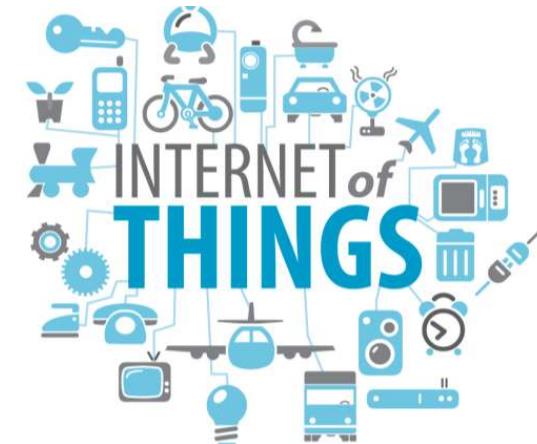
Internet of things



Everyday things get connected   for smarter tomorrow

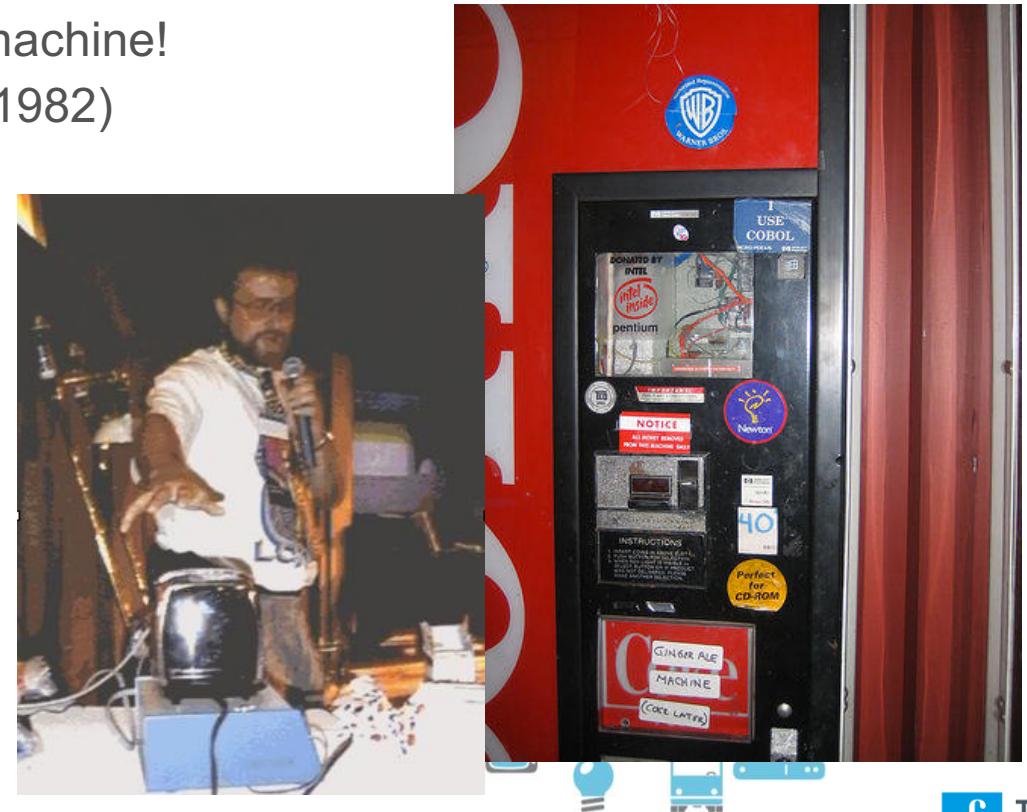
What is the IoT? (cont.)

- IoT encompasses areas as diverse as:
 - Embedded systems;
 - Wireless sensor networks;
 - Commodity sensors;
 - Control systems;
 - Automation;
 - Real-time analytics;
 - Machine Learning;
 - Computational Intelligence;
 - General Artificial Intelligence;
 - Etc.



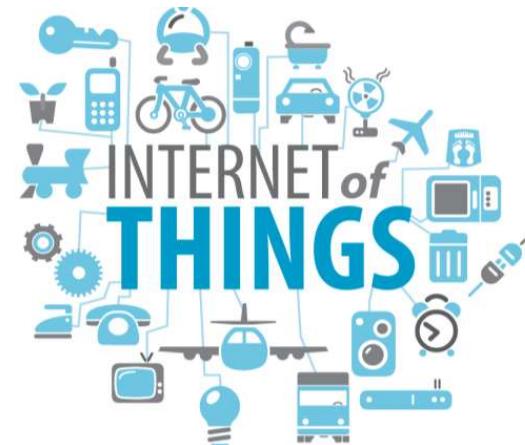
A bit of history...

- The first (non-computer) thing to be connected to the internet:
 - A Coca-Cola vending machine!
 - CMU CS Department (1982)
- Other contenders:
 - Internet Toaster
 - John Romkey (1989)
 - First to use TCP/IP



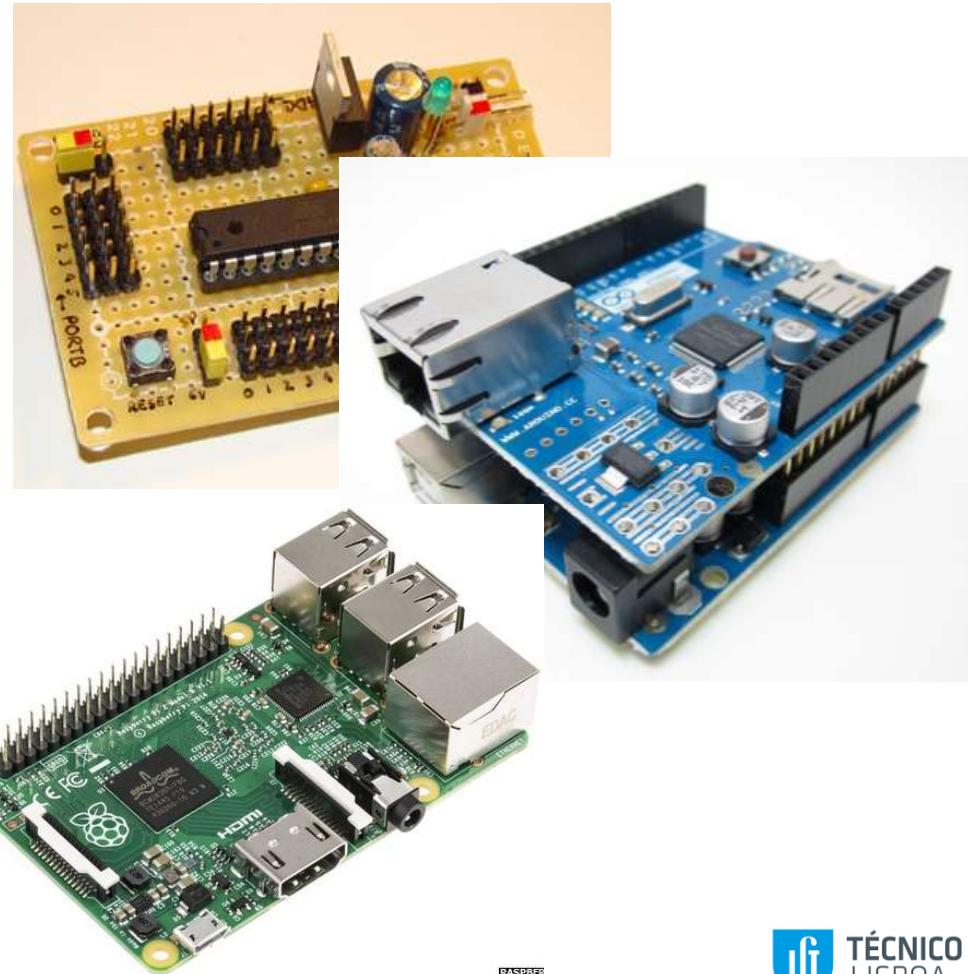
A bit of history... (cont.)

- 90's: Ubiquitous computing; MaW - Microsoft at work; NEST - Novell Embedded System Technology
- First time the term “Internet of (for) Things” was used:
 - 1999 (Kevin Ashton)
- 2008-2009: More “Things” connected to the Internet than people
- 2020: More than 30 Thousand Million (30×10^9) devices connected to the Internet
 - Earth population 7.8×10^9



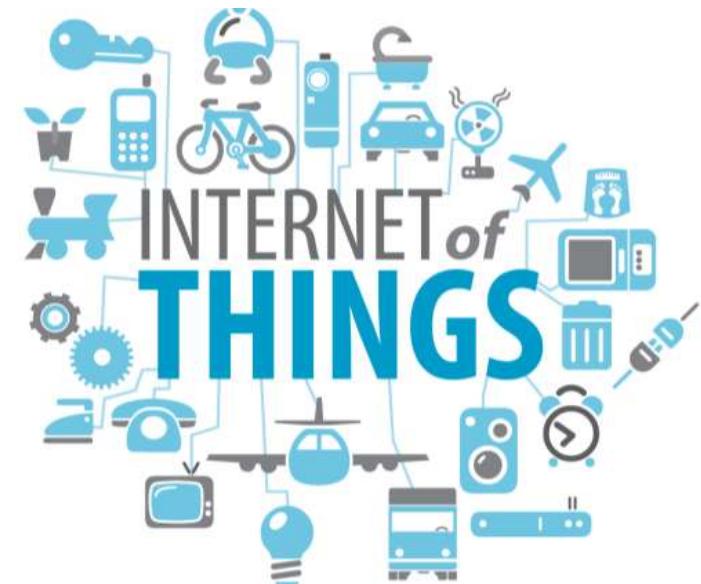
1999-2008: How did the IoT got traction?

- R: Open source hardware!
- Microcontrollers
 - Small programable devices
 - Easily connectable
- Arduino / Arduino Ethernet
 - As above, with simple to use open source software
- Raspberry Pi
 - Linux computer
 - More software oriented
 - Full networking system



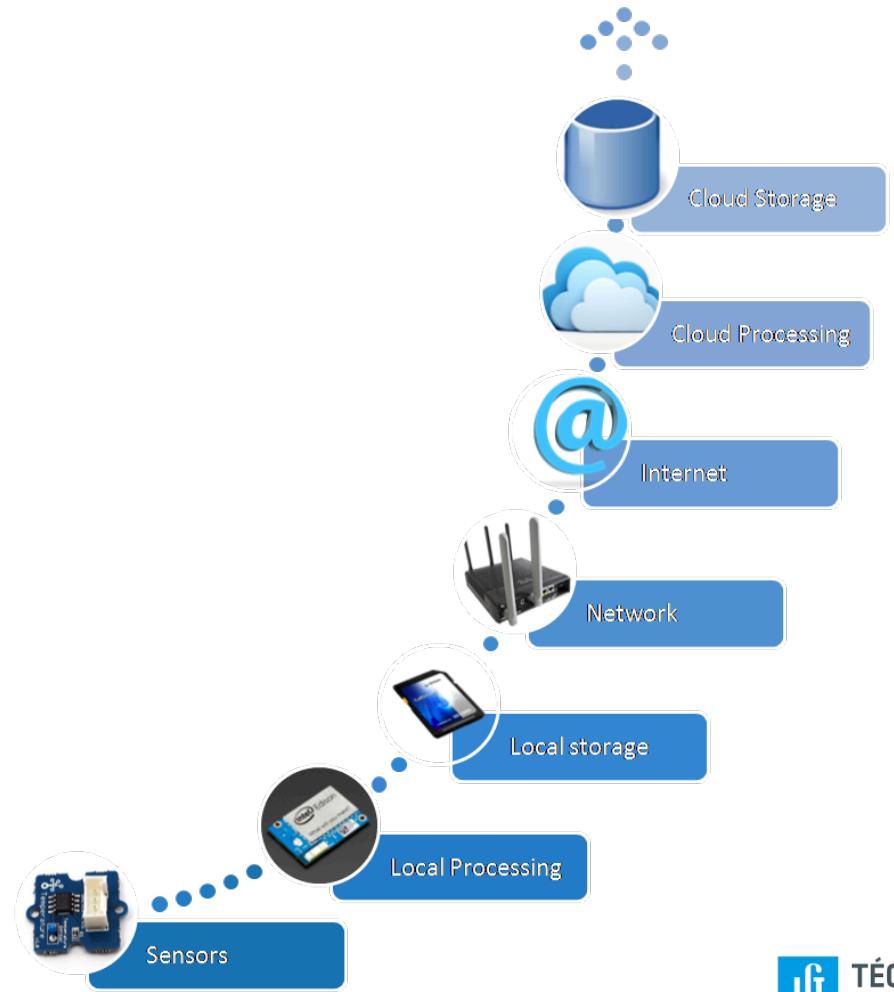
What drives the IoT?

- We want to receive more data
- We want to control stuff
- We want to automate
- We want to make things faster
- We want to turn the world into a better place 😊



IoT: An overview

- Cloud Storage
- Cloud Processing
- Internet
- Network
- Local Storage
- Local Processing
- Sensors



Sensors

- Sensor: A device that detects the changes in electrical or physical or other quantities and thereby produces an output as an acknowledgement of change in the quantity.
- Measure values
- Send raw data
- Low power
 - Speed sensors
 - Temperature
 - Infrared
 - Ultrasonic
 - Magnetic
 - Chemical
 - Optical
 - Etc.



Local Processing

- Get data from sensors
- Process data
- Send some data to Edge/Fog computing



Network and Internet

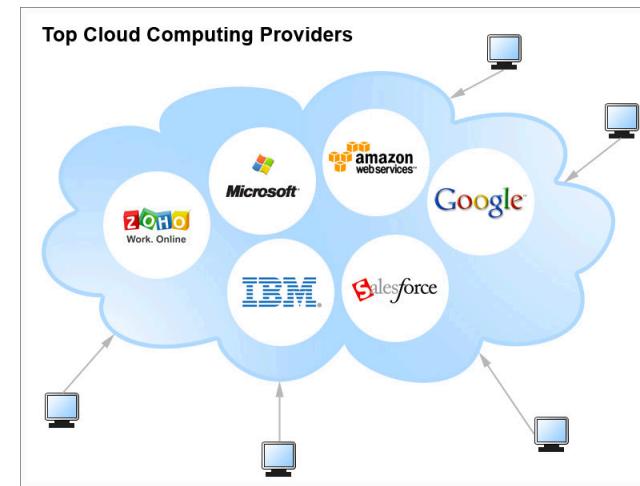
- IoT Gateway
- Gathers data from sensors
- Protocols
 - CoAP (Constrained Application Protocol – communication between small nodes and the Internet)
 - MQTT (Messaging Protocol for small sensors)
 - HTTP
 - XMPP (XML message-oriented middleware protocol)



Cloud Processing



- Aggregate data
- Inference
- Storage



IoT: Some Enabling Technologies

- Addressability:
 - From RFID to IP to URI
 - IPv6 essential for the sustainability of the IoT
- Application Layer:
 - Auto Discovery Resource Control (ADRC)
- Short-range wireless:
 - BLE (Bluetooth meshes); NFC; RFID; WiFi; ZigBee; Z-Wave (home automation)
- Medium-range wireless:
 - LTE; 5G
- Long-range wireless:
 - LPWAN (Low Power Wide Area Network): LoRaWan, Sigfox, NB-IoT
- Wired: Ethernet; Powerline

Intelligence and the IoT

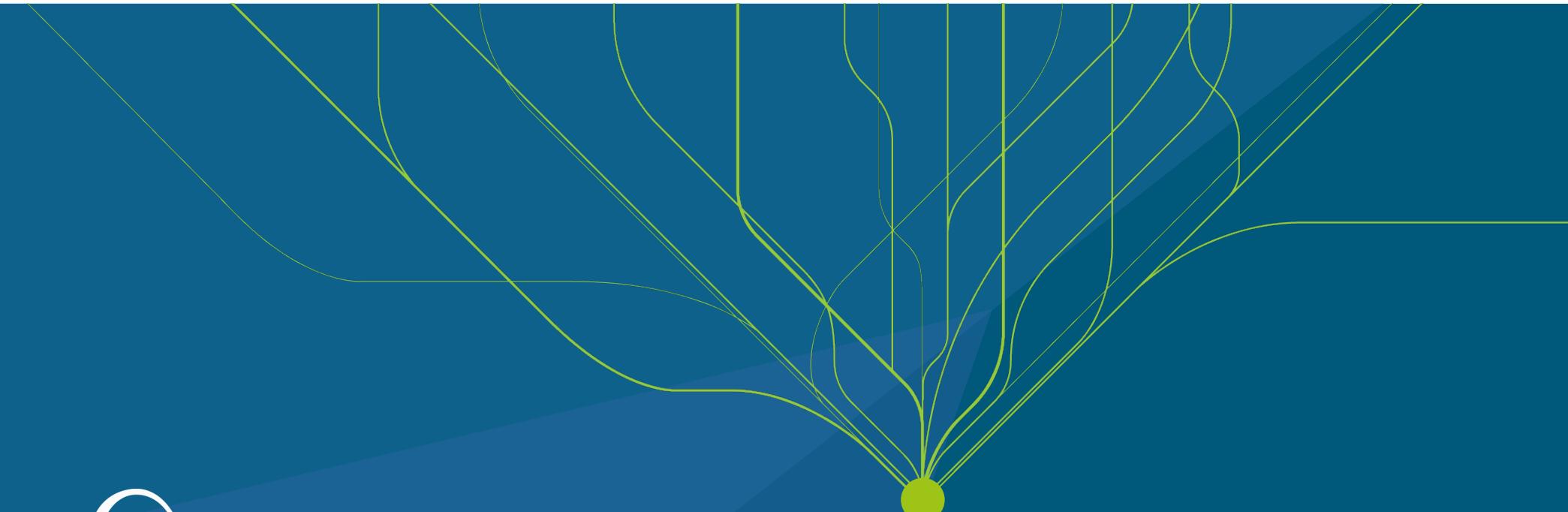
- Ambient intelligence and autonomous control are not part of the original concept of the IoT
 - However, current trends ask for it: autonomous vehicles; autonomous agents; personal digital assistants (Siri, Alexa, Google Assistant...)
- Intelligent approaches are useful (and often needed) at different levels of the IoT due to the volume of data and the need for low latency:
 - IoT devices (e.g.: gear shifts; vehicle detection and avoidance; etc.)
 - Edge/Fog nodes (e.g.: data cleaning and aggregation; image processing; V2V communication and synchronization; etc.)
 - Cloud Computing (e.g: data analysis; hidden information extraction; control decisions' prediction; etc.).
- Machine Learning, Computational Intelligence, AI: all have an increasingly important role within the whole IoT

Applications (shamelessly taken from Wikipedia)

- Consumer
 - Smart Home
 - Elder Care
- Commercial
 - Medical and Healthcare (IoMT)
 - Transportation
 - V2X (V2V, V2P, V2I, V2N,...)
 - Building and Home Automation
- Industrial
 - Manufacturing
 - Agriculture
- Infrastructure
 - Metropolitan scale deployments
 - Energy management
 - Environmental Monitoring
 - Living Lab
- Military Applications (IoMT)
 - Internet of the Battlefield Things
 - Ocean of Things

Challenges

- Privacy, Autonomy and Control
- Data Storage
- Security
- Safety
- Environmental Sustainability



A graphic element consisting of numerous thin, yellowish-green lines that radiate from a single point at the bottom center of the slide towards the top corners, creating a fan-like or sunburst effect against a dark blue background.

Thank you!
Obrigado!
/ ɔβri'gaðu/