Internet of Things
Introduction

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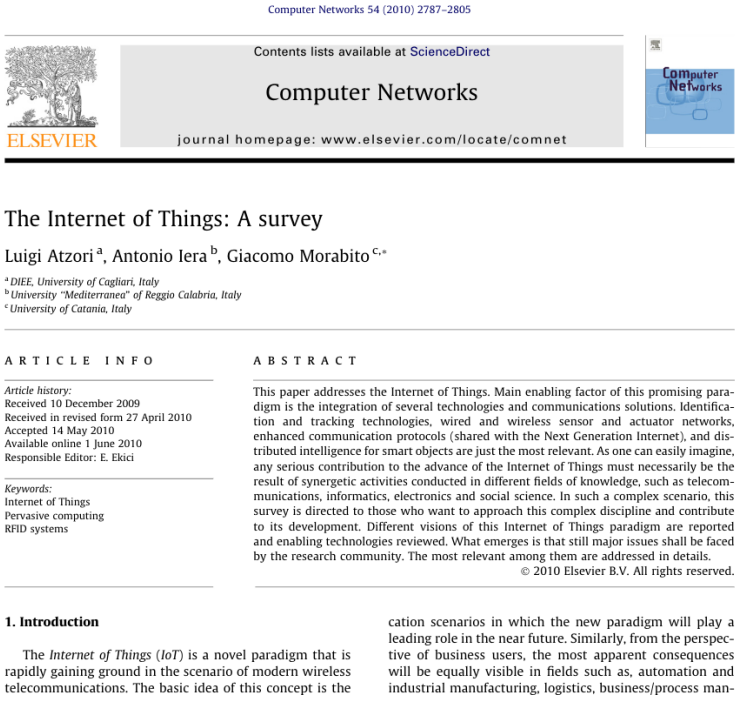
http://robot.unipv.it/toolleeo

The Internet of Things: definition

Many formulations of the same concept...



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The Internet of Things: A survey

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ABSTRACT

This paper addresses the Internet of Things. Main enabling factor of this promising paradigm is the integration of several technologies and communications solutions. Identification and tracking technologies, wired and wireless sensor and actuator networks, enhanced communication protocols (shared with the Next Generation Internet), and distributed intelligence for smart objects are just the most relevant. As one can easily imagine, any serious contribution to the advance of the Internet of Things must necessarily be the result of synergetic activities conducted in different fields of knowledge, such as telecommunications, informatics, electronics and social science. In such a complex scenario, this survey is directed to those who want to approach this complex discipline and contribute to its development. Different visions of this Internet of Things paradigm are reported and enabling technologies reviewed. What emerges is that still major issues shall be faced by the research community. The most relevant among them are addressed in details.

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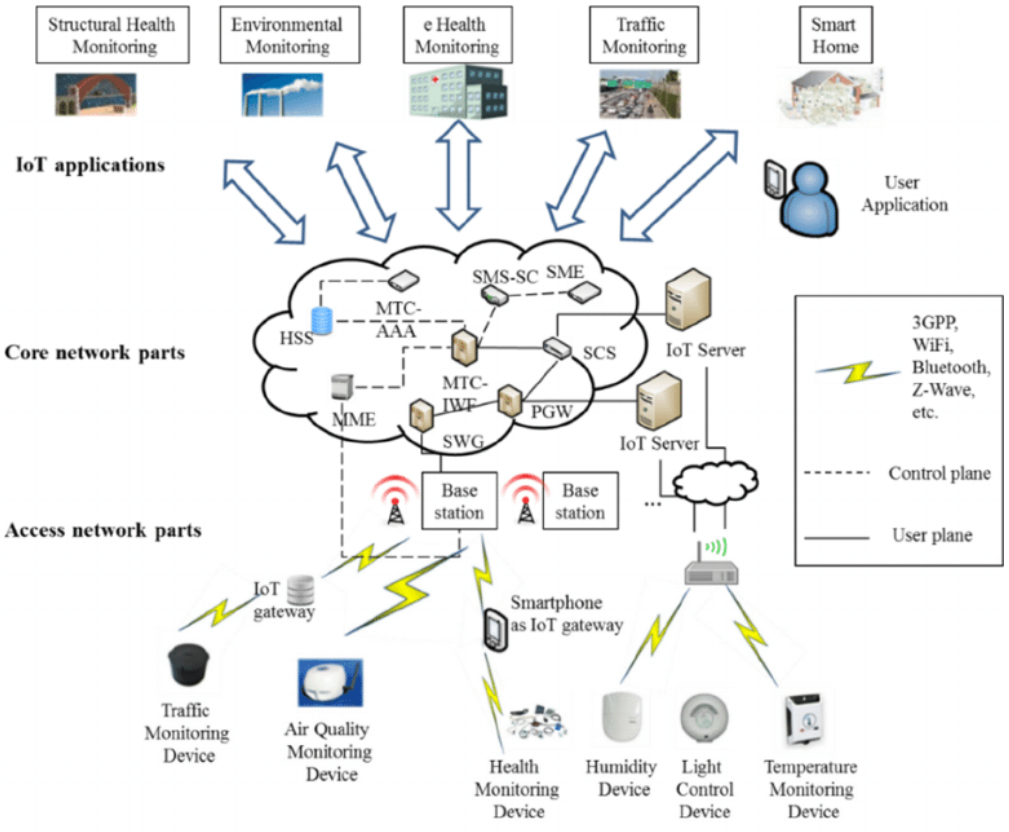
1. Introduction

The *Internet of Things* (*IoT*) is a novel paradigm that is rapidly gaining ground in the scenario of modern wireless telecommunications. The basic idea of this concept is the cation scenarios in which the new paradigm will play a leading role in the near future. Similarly, from the perspective of business users, the most apparent consequences will be equally visible in fields such as, automation and industrial manufacturing, logistics, business/process man-

"pervasive presence around us of a variety of things or objects – such as Radio-Frequency IDentification (RFID) tags, sensors, actuators, mobile phones, etc. – which, through unique addressing schemes, are able to interact with each other and cooperate with their neighbors to reach common goals"

D. Giusto, A. Iera, G. Morabito, L. Atzori (Eds.), "The Internet of Things", Springer, 2010.
ISBN: 978-1-4419-1673-0.

The Internet of Things: main components



Z. Abbas, W. Yoon, "A Survey on Energy Conserving Mechanisms for the Internet of Things: Wireless Networking Aspects", MDPI Sensors, 2015.

Core components:

- embedded devices
- sensors and actuators
- (wireless) networking

Other necessary components:

- data collections and storage
- data analysis
- user interfaces

Origin of the term

Kevin Ashton

- Co-founder of the Auto-ID Center at MIT, he first mentioned the Internet of Things in a presentation he made to Procter & Gamble (P&G) in 1999
- Ashton wanted to bring Radio Frequency ID (RFID) to the attention of P&G's senior management
- He called his presentation "Internet of Things" to incorporate a cool new trend of 1999: the Internet

Origin of the term

Neil Gershenfeld

- Professor at MIT
- Author of the book "When Things Start to Think"
- He didn't use the exact term but provided a clear vision of where IoT was headed

Convergence of technologies

- IoT was pushed by the advancements in wireless technologies, micro-electromechanical systems (MEMS), micro-services and the Internet.
- These technologies boosted the convergence between **Operational Technology (OT)** and **Information Technology (IT)**.
- The convergence enabled unstructured machine-generated data to be analyzed for driving improvements in the underlying process.

OT and IT: definitions

Operational Technology (OT): it is the practice of using hardware and software to control industrial equipments, and it primarily interacts with the physical world.

Information Technology (IT) systems: primarily used to solve business problems.

OT networks communicate with physical machines, while IT networks deal with information and data.

Source: `https://www.redhat.com/en/topics/edge-computing/what-is-ot`

Definitions: Wireless Sensor Network

Wireless Sensor Network (WSN) is a group of spatially distributed sensor nodes, which are interconnected by using wireless communication. A WSN may include one or more sink nodes (also called base stations).

- Born in 1950s for military applications.
- Huge scientific research in 1990s.
- Commercial applications in 2000s.
- As of 2010, WSNs had deployed approximately 120 million units worldwide [1].

[1] Oliveira et al. "Parametric Analog Signal Amplification Applied to Nanoscale CMOS Technologies", 2012.

Unstructured WSNs contain a dense collection of sensor nodes that may be deployed in an ad hoc manner into the field.
Structured WSNs deploy some of the sensor nodes are deployed in a pre-planned manner.

WSN vs. IoT

- WSN is an older and consolidated technology w.r.t. IoT.
- WSN and IoT are not alternative technologies.
- WSN is a building block to realize an IoT infrastructure.
- The IoT includes the full stack, while WSN is "limited" to sensor nodes and communication towards a sink.

Definitions: IIoT, Industry 4.0 and Edge Computing

Industrial Internet of Things (IIoT) is a subsection of the IoT that refers to connected devices that are used in manufacturing, energy, and other industrial settings. IIoT is commonly associated with OT and significant for bringing more automation and self-monitoring to industrial machines.

Edge computing involves shifting computing resources toward the physical location of either the user or the source of the data, like data analysis that takes place on a factory floor.

Industry 4.0: Overall change by digitalization and automation of every part of the company, especially in the domain of the manufacturing process.

First appearance of an IoT device

- Although Ashton's was the first *mention* of the term "Internet of Things", the idea of connected devices has been around since the 1970s.
- Previous terms were **embedded Internet** and **pervasive computing**.

- I.e., the first Internet appliance was a Coke machine at Carnegie Mellon University in the early 1980s.
- Using an Internet connection, programmers were able to check the machine and determine whether there would be cold drinks available.

From M2M to IoT

Machine-to-Machine (M2M) is a communication paradigm in which machines connecting to each other via a network without human interaction

M2M essentially was, and, in the industrial parlance is, still application-specific machine-to-machine communication with very definite functionality and expectations, with a controlled mode of communication.

Machine-to-Machine (M2M) communication is

- Communication between machines & devices.
- Involves no human intervention.
- Often takes place through telecom network.

M2M vs. IoT

- IoT evolved from M2M communication.
- As its foundation, M2M provides the connectivity for the IoT.
- IoT is about **Connected Intelligence**, a sort of universal global neural network in the cloud.
- Internet of Things is all about "heterogeneous" and "aware" devices interacting to simplify people's life in some way or the other.
- The IoT comprises of smart machines interacting and communicating with other machines, objects, environments and infrastructures.
- IoT takes M2M to the next level by connecting billions of smart devices with people, systems and other applications to collect and share data.

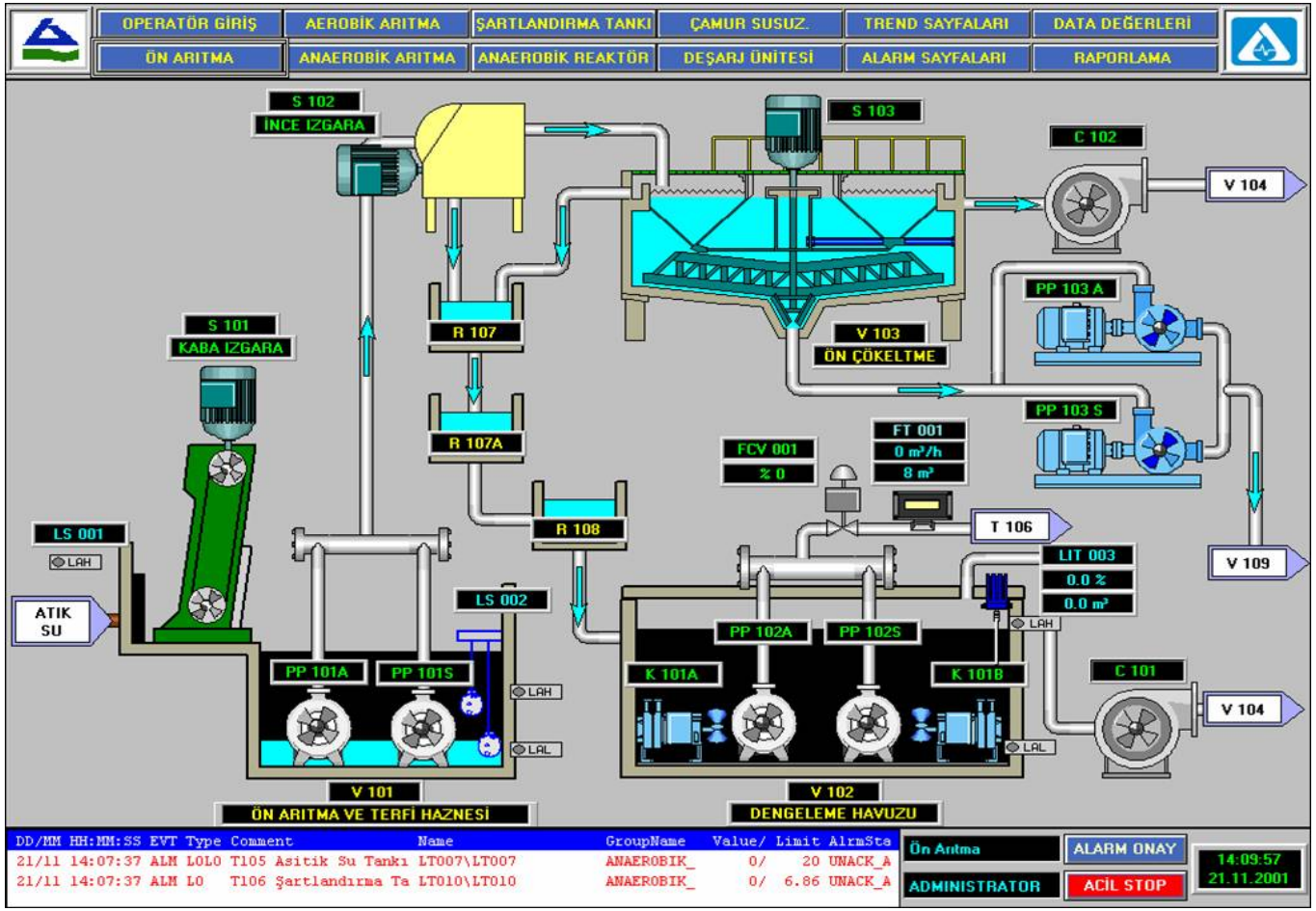
Relationship with process control and SCADA

SCADA (Supervisory Control and Data Acquisition) is a category of software application program for process control

- SCADA are used to colled data in real-time from remote locations and use it for controlling equipment and processes.
- SCADA systems include hardware and software components.
- The hardware gathers and feeds data into a computer that has SCADA software installed, where it is then processed and presented it in a timely manner.
- Late-generation SCADA systems evolved into first-generation IoT systems.

The Internet of Things is a natural extension of SCADA systems.

Example of SCADA MHI



Human Machine Interface (HMI) of a SCADA system for monitoring and controlling an industrial process.

IoT in the real world

- The concept of the **IoT ecosystem** wasn't really used in real world applications until a major actor made it a strategic priority.
- This happened in the **middle of 2010**, when the Chinese government declared it would make IoT a strategic priority in its next 5-year plan.

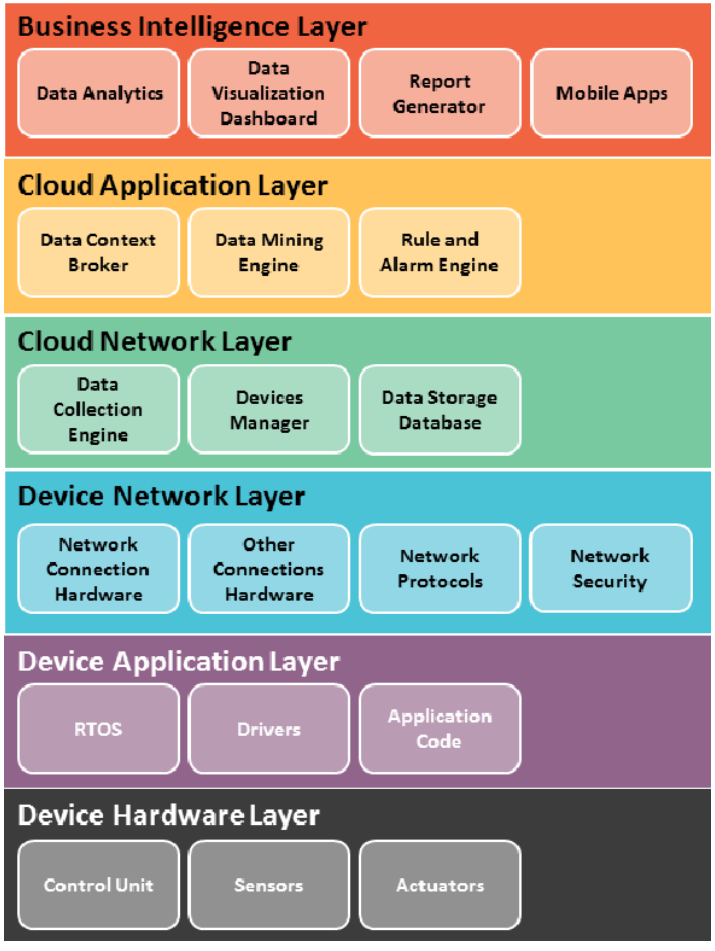
Components and stack

The IoT ecosystem is organized as a *stack*.
But what's a *stack*, after all?

> Stack: An **orderly pile**, especially one arranged in layers.
> from: any (online) dictionary

Examples:

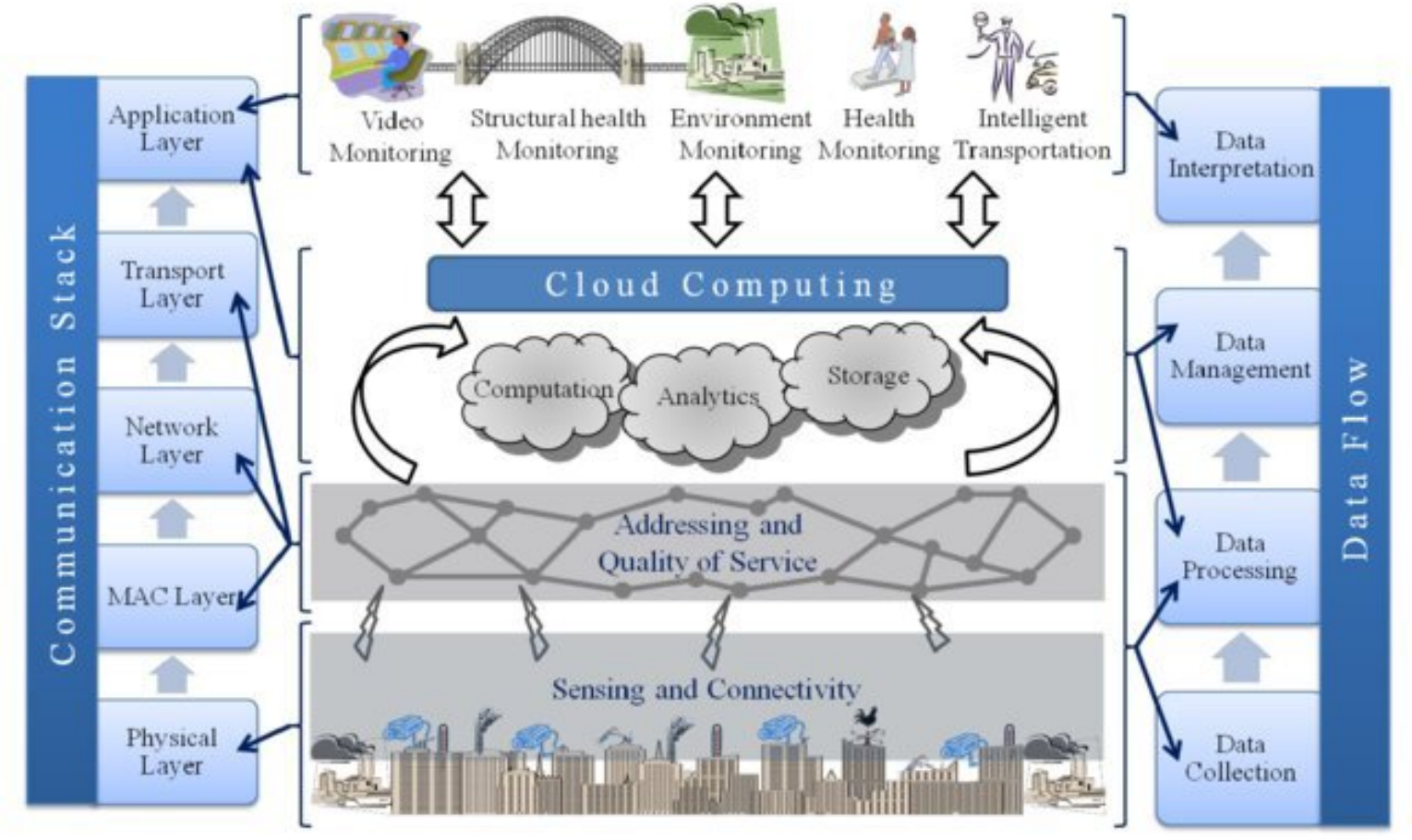
IoT stack



- modularized, layered architecture
- each layer has one specific purpose
- lower layers are closer to on-field devices
- higher layers are closer to the human operator
- data is (typically) exchanged between adjacent layers

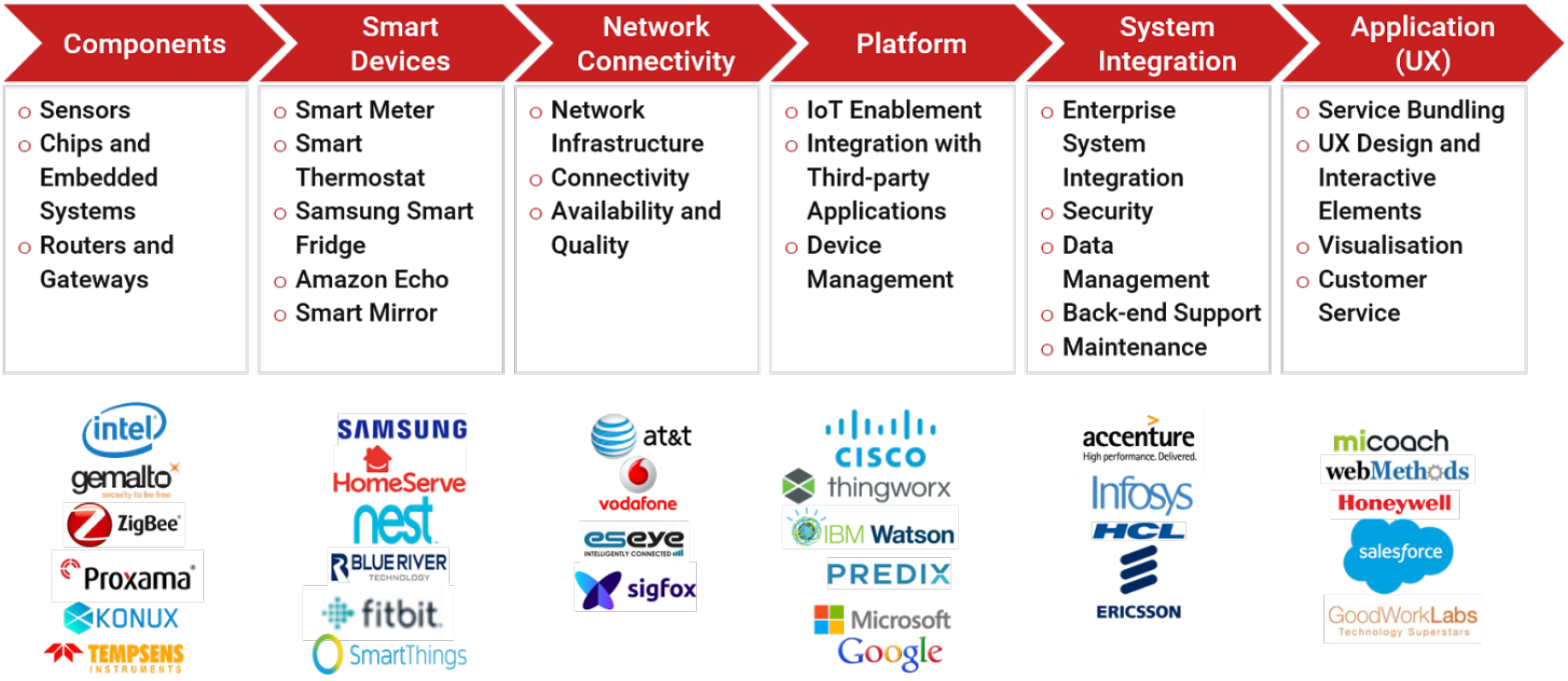
D. Mazzei, G. Baldi, G. Montelisciani and G. Fantoni. "A full stack for quick prototyping of IoT solutions", Cloudification of the Internet of Things (CIoT), 2016.

Components and stack



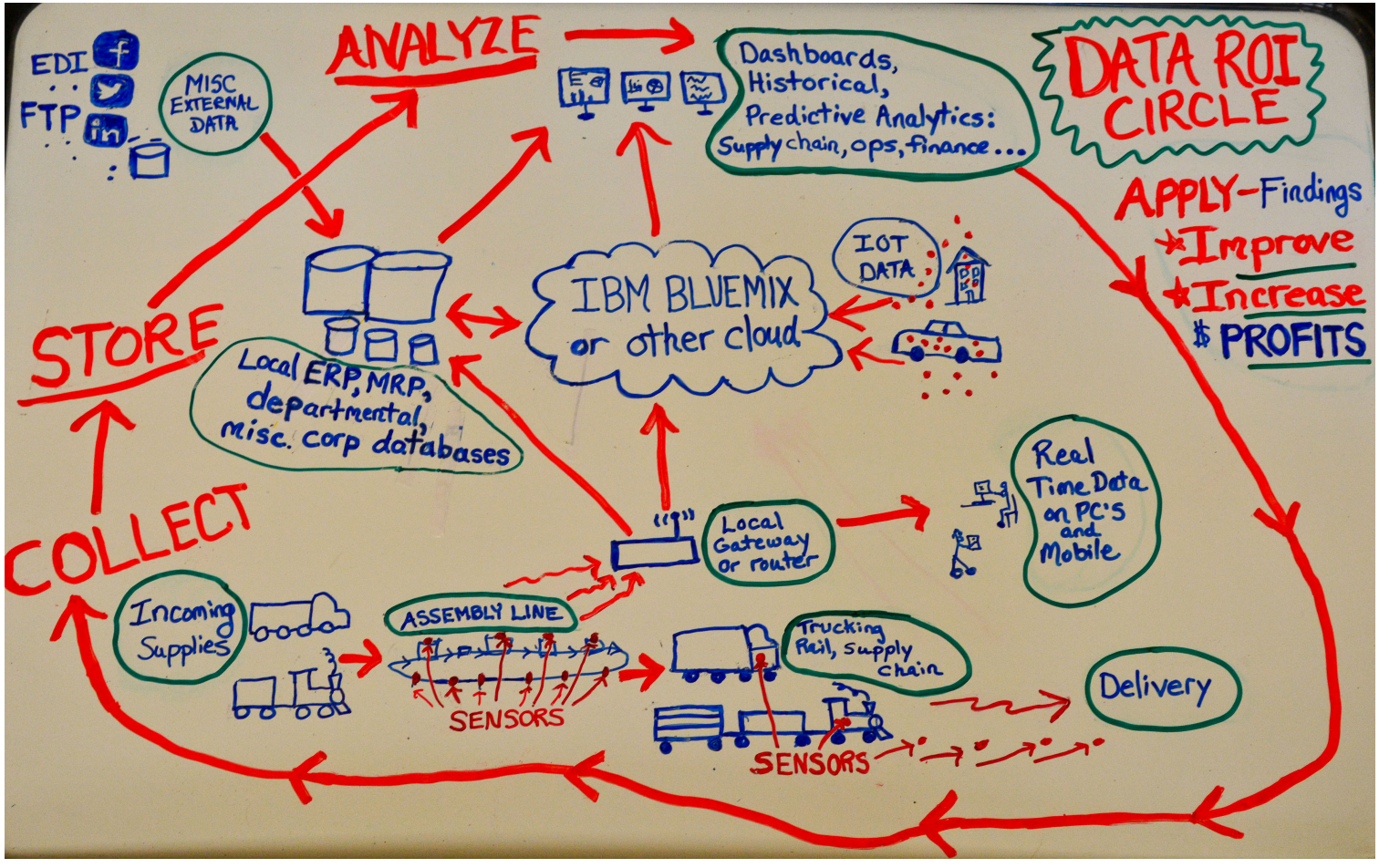
J. Jina, J. Gubbi, S. Marusic, M. Palaniswami, "An Information Framework for Creating a Smart City Through Internet of Things", Internet of Things Journal, IEEE, 2014.

IoT value chain



Source: gomedici.com/big-question-for-insurers-not-tech-but-whom-to-partner-with-for-iot-insurtech/

Data circle



Source: http://www.one-point.com/business-reporting-analysis/data-warehousing