Summary

We are living today in the Internet of Things (IoT) era, with a multitude of connected devices around us. These devices can be sensors, sampling every possible aspect of our life, actuators, taking an action depending on our input or automatic decision, or interfaces, such as computers and smartphones, presenting valuable information in a way that enriches or simplifies our everyday tasks.

The field of IoT has been growing steadily since its conception, 20 years ago, thanks to the technology improvements which made the devices used in this domain cheaper and cheaper, enlarging the spectrum of possible users.

The key of the IoT framework are the *data*. Data are the new gold or new oil of the Smart Societies era. Data can be used to better understand the current situation of a certain environment or device under test, so that it is possible to take the corresponding action in order to perform better at some particular task or improve life quality conditions for humans.

To build a scientifically sound and efficient IoT device is not a simple task. It may seem easy to retrieve, collect, store and analyze this kind of data. In reality, these are tasks that require much attention from various perspectives.

In the literature it is possible to find a plethora of articles trying to do so, but failing in one or more (or all) of these aspects. First, these data have to be gathered by a sensor with a certain accuracy and has an output consistent with the environmental conditions (i.e., it must not produce spurious data). Moreover, depending on the desired quantity to sample, one needs also to determine the correct sampling frequency, in order not to violate the Sampling Theorem. Second, according to the constraints of the environment and the requirements in terms of transmission timing, the data transfer protocol has to be carefully chosen. Third, the data have to be stored in a certain structure depending on usage requirements (CSV files, databases, Distributed Ledger Technology, etc.). This thesis reports a detailed analysis of the most critical issues in the design and implementation of an IoT device, taking into account: the correctness of the data gathered; the optimization of the power consumption in relation to the signal to be sampled; the analysis of different wireless technologies that can be used to transmit the gathered data; the conjuncture of IoT and Blockchain paradigms for the sake of data authenticity and safe storage of sensible data. As a side topic, this thesis

also discusses another breakthrough in the Computer Science domain: Quantum Computing. This new computing paradigm is changing the landscape of a variety of human endeavors, from computing, to physics, to chemistry. The basic concepts are described, along with the possibilities this mindset entails and the consequences of such advanced computing power, which could impact directly the IoT/Blockchain implementation discussed.

Summarizing, the main contributions of this thesis are the following:

- *Ensuring scientifically-sound data exploiting low-cost sensors*
  The topic is addressed by focusing on the case study of air pollution monitoring. It is reported the design and development of a Particulate Matter monitoring station via a rigorous evaluation of sensors and calibration procedures. The resulting platform serves as proof-of-concept for the creation of densely deployed networks of low-cost sensors to work in synergy with reference-grade devices in order to create finer-grade air pollution maps.

- *Evaluation of wireless protocols for the task of indoor transmission of IoT data*
  The topic is addressed by considering the task of indoor thermal monitoring. In this context, two widespread wireless technologies, RFID and Bluetooth, have been compared both theoretically and via a series of meticulous in-field tests to assess their operating range, transmission efficiency, scalability, and resilience to interference.

- *Integration of IoT and Blockchain domains*
  This thesis reports the integration of the Blockchain Distributed Ledger Technology in the context of IoT. This implementation serves as the missing block with which it is possible to make IoT devices communicate with an open blockchain. This could enable true transparency in several manufacturing processes.

- *Analysis of new possibilities and threats posed by Quantum Computing*
  As a side topic, this thesis addresses the emerging field of Quantum Computing. The possible applications of such a new paradigm are reported, along with new threats posed to encryption schemes used today.