

# An advanced traceability system based on semi-active RFID devices

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**Abstract** – In this paper an innovative system for the traceability of products along all the production chain is proposed. The presence of semi-active RFID module integrating suitable sensors allows the remote monitoring of the storage and transport conditions. The main novelty is constituted by the On Board Unit (OBU), installed on the vehicle, which is the connection between the vehicle itself and the central system. The OBU works both as a concentrator node, for the wireless network composed by the semi-active RFID devices, and as a RFID reader.

## I. INTRODUCTION

Traceability is defined as the ability to trace the history, use or location of which is being considered [1]. The internal traceability is limited to the design cycle of a given product and is easily confined to a single place of work, or even to a single company; whilst the supply chain traceability is therefore the ability to reconstruct the history and to follow the use of a product, from raw materials to consumer products. A delicate aspect is the monitoring of goods in transit, especially for perishable goods [2], which the constant monitoring of the quality of the environment in which they are placed during transport, it is a very important issue for [3],[4].

Depending on the application areas, it is necessary to refer to specific regulation. In the agribusiness trade the

community legislation has as its main purpose the hygiene of the products and the consumer safety [1]. In Italy traceability is well regulated in pharmaceutical and waste disposal range.

The purpose of an advanced tracking system is to monitor the product not only in production but also in all the different stages of the supply chain, including the inter-factory transportation. The encoding of the information to be transported is very important for the traceability system. Among the most used techniques, the radio-frequency identification (RFID) tags [5] are becoming more and more widespread. The reader is used to remotely read and write data on the smart tag in real time, it sends an activation signal to the tag, which responds with the transmission of information loaded into memory. In meat traceability range, RFID technology is already widespread, as well as for the antishoplifting.

In this paper, an innovative system for advanced traceability [6] based on semi-active RFID module. The tracking system includes the geographical localization of each single item (not only the localization of the vehicle, like several existing traceability systems), related to the sensor values and the OBU number, monitoring the storage and transport conditions of the products. In the following, all the main components of the proposed system are described evidencing details.

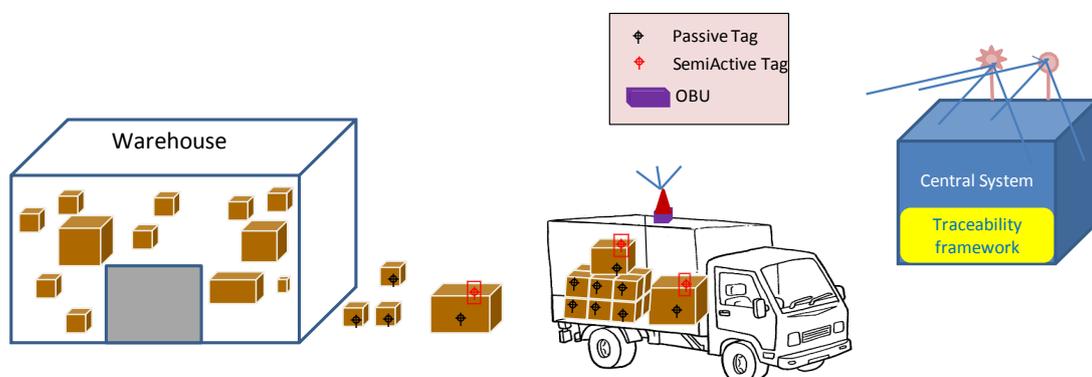


Fig. 1. The traceability system.

## II. THE PROPOSED TRACEABILITY SYSTEM

A generic system based on the RFID technology needs three main part: TAGs, an RFID reader and an elaboration system. The TAG, also known as transponder, is composed by a small and simple integrated circuit (equipped with simple logic and control functions and a small memory) connected to an antenna. The integrated circuit and the antenna could be incorporated in labels, boxes or smart cards; it is possible to classify them in passive, active and semi-passive type, depending on the energetic source management and on the type of communication. The RFID reader is a radio transmitter and receiver: the task of the reader is to query the all the TAGs in the antenna field and to receive data from the TAGs. A reader for passive and semi-passive TAGs have to radiate RF signals capable of providing to the TAGs also the energy for the response. Whereas a reader for active TAGs could use different radiofrequency communication techniques. The elaboration system is connected to the reader, it receives data acquired by the reader and it can manage and elaborate those data.

In Fig.1, the proposed traceability system is schematically shown. It is possible identify three main parts:

- i. TAGs,
- ii. On Board Unit (OBU),
- iii. Central System.

All the packages to be tracked are labeled with a passive TAG [5] that uniquely identifies them: it stores the unique code of the product. The reader transmits interrogator signals and all the TAGs, which are in the antenna field, respond with the unique identifier (utilizing an anti-collision protocol), and some other data stored in the memory of TAGs.

Several special packages are featured also with a semi-active TAG that integrates sensors, in order to monitor the preservation of environmental conditions. In the proposed system passive TAGs are used also for the semi-active TAGs: they communicate data related to the sensors on a different communication radio channel to the OBU.

The OBU works as a concentrator and communicates all the acquired information to a central system; OBU and active TAGs are then nodes of a wireless sensor network [7]-[11].

### i. TAGS

#### A. Passive TAGs

The used TAG are the ALN-9662, by Alien®; it uses EPC Gen 2 coding, RFID UHF operation (840-960MHz). It is pre-programmed with a 64-bit serial number. The User Memory can be write, and it is possible to protect the data with password in 64-bit blocks.

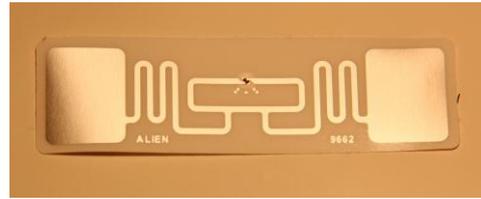


Fig. 2. The passive TAG

#### B. Semi-active TAGs

The semi-active TAG is based on the CC1111Fx by Texas Instruments® includes temperature, humidity and light sensors. Each semi-active TAG is related to a passive TAG storing the ID of the microcontroller in the passive TAG user memory. The sensor data are acquired with a period of five seconds, and the measured values are pre-processed on board, finally the outputs are sent to the OBU.

### ii. OBU

The OBU acts as linker between the vehicle and the traceability platform (see Fig.3); consequently, its tasks are numerous, it has to collect all the information on the vehicle status and operates as a wireless network concentrator [7], it always has to be geographically localized and continuously sends data to the central system. The core of the system is a microcontroller, furthermore it is featured with several modules: the RFID reader, the wireless sensor network concentrator, the GPS/GPRS module,

The OBU prototype is schematically shown in Fig. 4: it is based on STM32F103RE microcontroller, manufactured by STMicroelectronics, in ARM Cortex M3 technology.

The RFID reader used for the prototype is the OEM RFID UHF ISC.MU02.02 module by Feig Electronic®. It

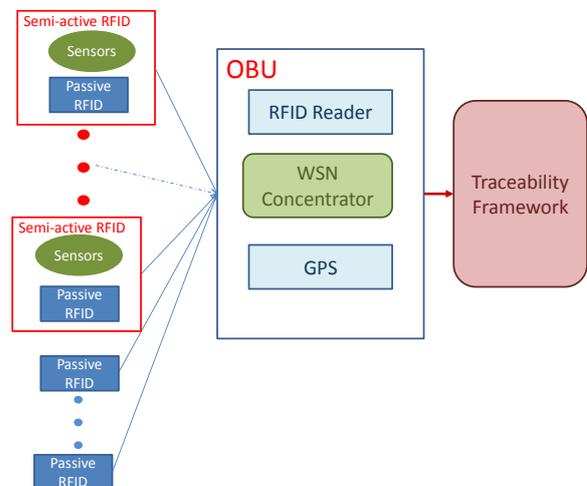


Fig. 3. The traceability system architecture

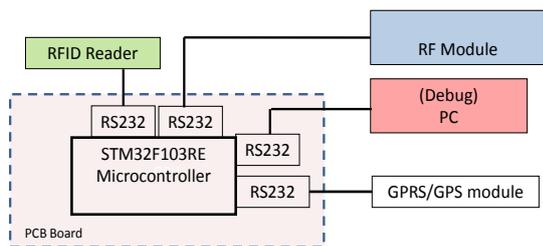


Fig. 4. Block diagram of the OBU microcontroller interfaces

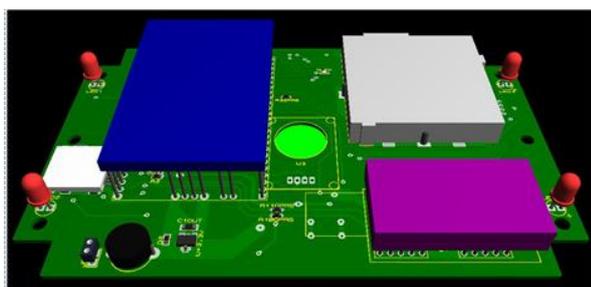


Fig.5. The block diagram and the layout of the OBU

works in the 860÷960 MHz (UHF) frequency range, and is suitable for short and medium distance range and is characterized by low power consumption. The read TAG codes are periodically sent to the OBU. The wireless sensor network module is based on the CC1111Fx by Texas Instruments® (the same also used on the semi-active TAGs). The GM862-GPS module by Telit, that integrates GPS/GPRS functionality, are also featured.

All these devices are interfaced via RS232 to the OBU microcontroller [8],[9]. The GPS module gives the geographic location and time. The OBU is also equipped with an SD memory since the system requires a memory buffer, to save the information when the system cannot send data to the server.

The OBU periodically read data by the semi-active TAGs, the communication is made by a star topology with a carrier to about 868MHz. The used protocol is SimpliciTI by Texas Instruments. After the acquisition and processing phases the microcontroller creates a data packet for each minimum traceable unit and sends data to a server through the GPRS module.

### iii. The central system

The central system is a server which receive and manage conveniently all the information acquired by every OBU. Data, continuously sent from vehicles, are plenty; moreover not all are needed in real time by the traceability platform. As a result, the OBU is programmed in order to being able to transfer, via GPRS, to the platform, only the data that must be updated in real

time.

The multitude of generated information by RFID system could be noteworthy, therefore it could be difficult to manage and memorize data. Data packets are organized in strings, with information related to the EPC, position, time and, in the case of semi active tags, the acquired value of the sensors.

The server processes the received packets, visualizes on a map the package localization and shown all the collected data concerning the condition of each special package (Fig. 6). In the strings sent by the OBU are included also the position of the object to be traced, obtained with the GPS module. Therefore, localization of the product depends on the position of the vehicle, as long as it is still on board. Moreover some alarm indications are provided in case of the specifications on the storage condition are not satisfied or the package route is not followed.

Then, the task for the central system (see Fig.3) is really important, and allows, online, the data received management depending on the specific application, with a management information system. With this system, it can be visualized both the route traveled by each single package, and also the environmental conditions with which it was delivered. All the temperature variations suffered by the package (for example, in case of perishable goods, it could be useful for food and drugs), the brightness or humidity variations, related to all the data about the time and the position of the acquired values, achieving a real traceability system of the environmental conditions. Further developments of this system could be various, depending on the needs: in case of one or more packages indicate the exceeding of the predetermined threshold values for a certain amount of time, the central system, in addition to the management of those advices, could communicate directly, warning the driver of the transport.

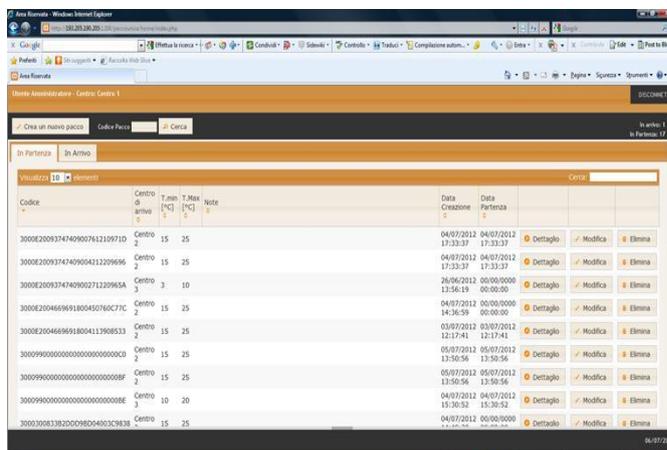


Fig. 6. Example of the user interface

### III. CONCLUSION

In the paper an innovative architecture for a traceability system is described. Thanks to the adopted solutions both in the semi-active devices realization and on the wireless sensor network [10], [11] implementation allow the continuous tracking of packaging also in the transportation phase. The focus key of the proposed solution is the designed on board unit that integrates realizes several features. Many other type of sensor could be included in the semi-active TAGs and several further elaboration can be done fusing the sensor and the GPS data. Further researches will focus to give to the system also seal capability in order to increase the security of the vehicle.

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