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Tracking in product delivery using portable RFID with arduine

Rastreamento na entrega de produtos utilizando RFID portátil com arduino

Seguimiento de la entrega de productos mediante RFID portátil con arduino

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Abstract

This study aimed to develop a device for traceability of the goods delivery process, using radio frequency technology (RFID), which will inform the date, time and location where the goods are being delivered to the end customer. The methodology used consisted of three stages: 1) data collection through a portable collector along with RFID tags, 2) data processing by the microcontroller and 3) carrying out the consultation of the information contained in the tag through the communication between the RFID and the Arduino, whose product traceability was carried out through radio frequency sending information via GSM; while the materials used were 1 mega arduino board, 1 6m Neo GPS shield, 1 Sim 900 module, 1 RC522 RFID reader, 1 16x2 graphic LCD display and 1 keychain RFID tag. For testing the sending of date, time, product specifications and location information via SMS to the registered cell phone at the time of product delivery, operations were carried out in different locations with different dates and times and the messages were sent without fail. The results confirmed the display of the information “Data Collected Successfully” on the LCD

display, after the reading of the LCD label by the collector. The proposed prototype proved to be effective, managing to control the delivery of low-cost goods through passive tag on a portable RFID reader.
Keywords: Portable RFID; Product tracking; Arduino; Delivery tracking.

Resumo

Este estudo teve como objetivo desenvolver um dispositivo para rastreabilidade do processo de entrega de mercadoria, através da tecnologia de rádio frequência (RFID), o qual informará a data, hora e localização onde a mercadoria está sendo entregue ao cliente final. A metodologia utilizada consistiu de três etapas: 1) coleta dos dados através de coletor portátil junto as etiquetas RFID, 2) processamento dos dados pelo microcontrolador e 3) realização da consulta das informações contidas no TAG por meio da comunicação entre o RFID e o Arduino, cuja rastreabilidade do produto foi realizada através de rádio frequência enviando informação via GSM; enquanto que os materiais utilizados foram 1 placa de arduíno mega, 1 shield GPS Neo 6m, 1 módulo Sim 900, 1 leitor RFID RC522, 1 display de LCD gráfico 16x2 e 1 TAG RFID do tipo chaveiro. Para os testes do envio de informações de data, hora, especificações do produto e localização via SMS para o celular cadastrado no momento da entrega do produto, foram realizadas operações em diversos locais com datas e horas diferentes e as mensagens foram enviadas sem falha. Os resultados constataram a exibição da informação "Dados Coletados com Sucesso" no display de LCD, após a realização da leitura da etiqueta de LCD pelo coletor. O protótipo proposto se mostrou eficaz, conseguindo realizar o controle de entrega de mercadorias de baixo de custo por meio de etiquetas passivas em um leitor portátil RFID.
Palavras-chave: RFID portátil; Rastreamento de produto; Arduíno; Rastreamento de entregas.

Resumen

Este estudio tuvo como objetivo desarrollar un dispositivo para la trazabilidad del proceso de entrega de la mercancía, mediante tecnología de radiofrecuencia (RFID), que informará la fecha, hora y lugar donde se entrega la mercancía al cliente final. La metodología utilizada consistió en tres pasos: 1) recolección de datos a través de un colector portátil junto con etiquetas RFID, 2) procesamiento de datos por el microcontrolador y 3) realización de la consulta de la información contenida en el TAG a través de la comunicación entre el RFID y el Arduino , cuya trazabilidad de producto se realizó mediante envío de información por radiofrecuencia vía GSM; mientras que los materiales utilizados fueron 1 placa mega arduino,

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1 escudo Neo GPS de 6m, 1 módulo Sim 900, 1 lector RFID RC522, 1 display LCD gráfico 16x2 y 1 llavero RFID TAG. Para probar el envío de fecha, hora, especificaciones del producto e información de ubicación vía SMS al celular registrado en el momento de la entrega del producto, se realizaron operaciones en diferentes ubicaciones con diferentes fechas y horas y los mensajes se enviaron sin falta. Los resultados confirmaron la visualización de la información "Datos recopilados con éxito" en la pantalla LCD, después de la lectura de la etiqueta LCD por parte del recolector. El prototipo propuesto demostró ser efectivo, logrando controlar la entrega de mercancías de bajo costo a través de etiquetas TAG pasivas en un lector RFID portátil.
Palabras clave: RFID portátil; Seguimiento de productos; Arduino; Seguimiento de entregas.

1. Introduction

The logistics challenge is to reduce the loss of resources, money and time as much as possible (Akram & Siddiqui, 2019; Guanxiang et al., 2019) through an efficient transport system (Bäumler & Kotzab, 2020). Tracking systems are created for these specific purposes (Yau et al., 2020; Tatatinov & Kirsanov, 2019), where information becomes the essential raw material for this purpose (Ho et al., 2018). Several technologies have been developed to perform product tracking, as attested by the studies by Wallis et al. (2020), Majorov, Taratun and Fetisov (2020), Evtodieva et al. (2020) and Kim et al. (2020), among many others.

Despite all this effort, there are still large numbers of complaints about the delivery system of companies, mainly mechanical problems, deviation of route and delivery of wrong goods. Against this backdrop, this study presents a delivery tracking solution using RFID technology. The RFID (Radio Frequency Identification) technology has been presenting itself as an important tool in the search for quality in the information flow, presenting great potential for application in several segments. It has aroused interest in large manufacturers and retailers, due to the potential it presents to simplify and make the automatic identification of products more efficient, providing a high degree of integration, as shown by studies by Elewe and Zaboon (2020), Smith (2020) and Asan et al. (2020). The mobile collector created uses RFID technology to send the following data to the company's headquarters: date, time and geolocation at the time of delivery of the goods.

The dynamics of the problem begins when the plant has no communication with the fleet at the time of delivery, numerous situations arise that can cause the dissatisfaction of the end customer. Most current delivery models are out of date. Although there are numerous monitoring technologies, companies are held hostage by equipment at an extremely high cost to manage this logistical challenge. Numerous situations can happen to generate even more damaging results, such as the driver deviating from his route, possible delays in a certain customer or mechanical problems with the transport vehicles.

Proper management of this logistical process is inefficient. With unrealistic data filled in the forms of transport and delivery by employees, such as the wrong delivery time, leaving the end customer dissatisfied. All these factors show the real need to automate the delivery system using tracking tools.

The motivation for carrying out this study came from the observations and several experiences of carrying out these activities using the manual method. This technique uses paper and pen to make the necessary notes at the time of delivery, which leaves a gap open when it is time to write off the company's stock, in the same way that compromises the punctuality of each delivery. The automation of this activity will allow the progress of operations with greater agility and greater efficiency for data collection and other operations.

Thus, this study aimed to implement and use hardware to assist companies in the process of automating the delivery of goods in real time in an independent manner. Through a radio frequency reader (RFID), the mechanism will inform the date, time and location where the goods are being delivered to the end customer. The steps taken for this purpose were: a) searching the literature for techniques related to RFID and Arduino microcontroller for the construction of the prototype, b) adapting the techniques for the implementation of an alternative system using RFID technology; c) experimentation in a case study of the prototype of a portable RFID reader together with the tags to perform data collection; d) development of communication between the RFID reader and the organization using the mega Arduino microcontroller; e) production of a low-cost and easy-to-implement system to be used immediately and f) sending information, such as date and time and location (GPS), using GSM technology from one location to another. As many companies still use manual and obsolete systems to deliver goods, they face common problems of human error. The implementation of this technology is an advantageous solution, as it seeks to promote improvements, such as agility in the collection of information, reliability, cost reduction and increase in the level of customer satisfaction.

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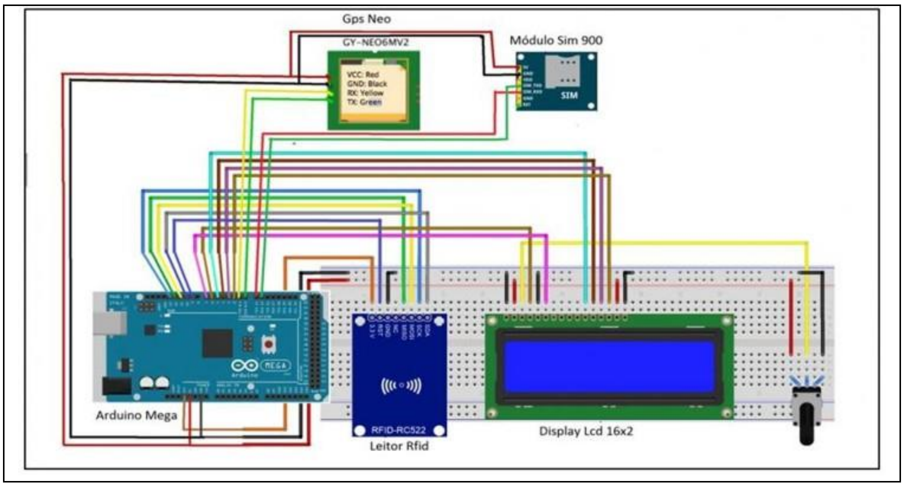
2. Materials and Methods

This study proposed the implementation of a product tracking prototype using radio frequency sending information via GSM, with the methodology suggested by Nascimento-e-Silva (2012; 2020a; 2020b). For this it was necessary to use 1 mega arduino board, 1 Neo 6m GPS shield, 1 Sim 900 module, 1 RC522 RFID reader, 1 16x2 graphic LCD display, 1 male-female jumpers kit, 1 protoboard and 1 RFID tag keychain type. Figure 1 shows a scenario containing the components of the project.

Figure 1. Physical architecture.



Source: Created by the authors.

The logical design consisted of three stages: data collection by the portable collector along with the RFID tags, data processing by the microcontroller and the consultation of the information contained in the tag through the communication between the RFID and the Arduino. All communication between the internal components of the collector and the RFID tags were programmed in the Arduino Mega microcontroller and the collected information was stored in the internal memory of the microcontroller. Figure 2 shows the flowchart of the communication steps between the reader components and the labels.

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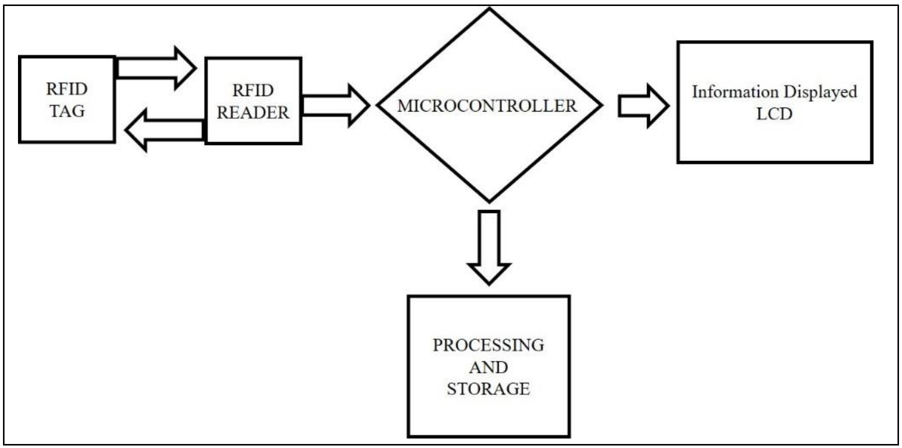
Figure 2. Logical architecture of the Project.



Source: Created by the authors.

Step 1: it was necessary to bring the RFID tag close to the RFID reader so that the system received information in the form of a code. Each tag had a different code than the other to identify the type of information contained therein. This code sent by the label was associated with a product information block, this information being contained in the programming of the Arduino microcontroller, where it was associated with the label code with the product information block.

Step 2: the tag information collected by the RFID reader was displayed on the LCD display and automatically sent to the Arduino microcontroller. The latter processed the information from the label codes and associated them with the information in which that code was contained, storing the data in its own memory.

Step 3: the microcontroller asked the GPS shield for the current location of the object's delivery. At that time, the collected information was displayed on the LCD display, which was displayed to the user who was carrying the collector. In this information transmission process, data from a given label was successfully collected. This ensured that the reader's approach to the label caused communication and information exchange to occur.

Step 4: the system was able, through the Sim900 Module, to send the data of date, time, product specification and location via SMS to the registered mobile number at the time of delivery. The prototype used to perform the tests is shown in Figure 3.

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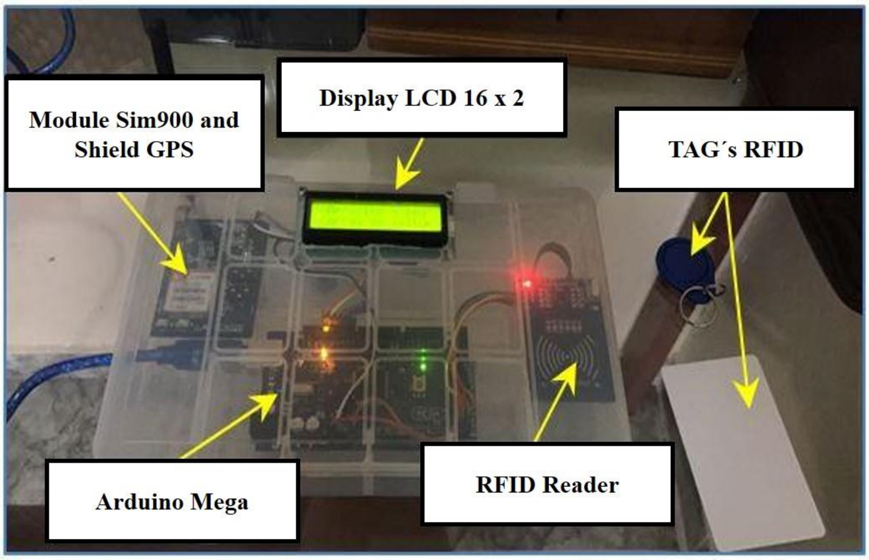
Figure 3. RFID Tracker prototype.



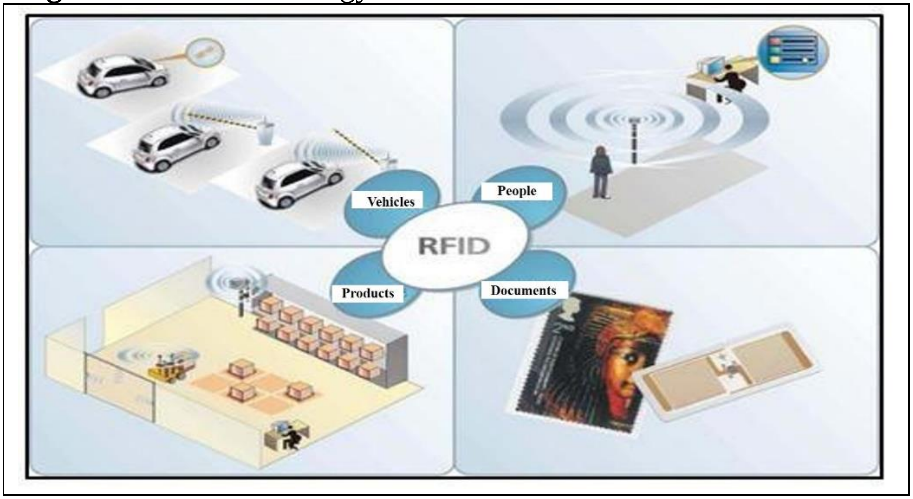
Source: Created by the authors.

3. RFID technology and communications

RFID is a technology that uses radio frequency to capture data and identify objects automatically through the specific codes of each component. According to Godoy (2011), RFID technology is a branch of self-identification technologies (Auto-ID), more precisely, of wireless self-identification technologies. An Auto-ID technology is an automatic identification technology, that is, it identifies people or objects automatically through a specific code. To exemplify, one can mention the case of the barcode, the Fingerprint, which uses fingerprints to identify people, and so on. In the case of RFID, it is no different. It uses radio frequency electromagnetic waves as a vehicle that carry the unique identification code of items (people, animals, equipment and materials) recorded on a chip for other systems.

Through a chip integrated in the objects it is possible to track the items in real time, being able to replace the bar codes attached to the objects to be monitored. Figure 4 exemplifies the different areas of activity in which RFID technology can be used.

Figure 4. RFID technology.



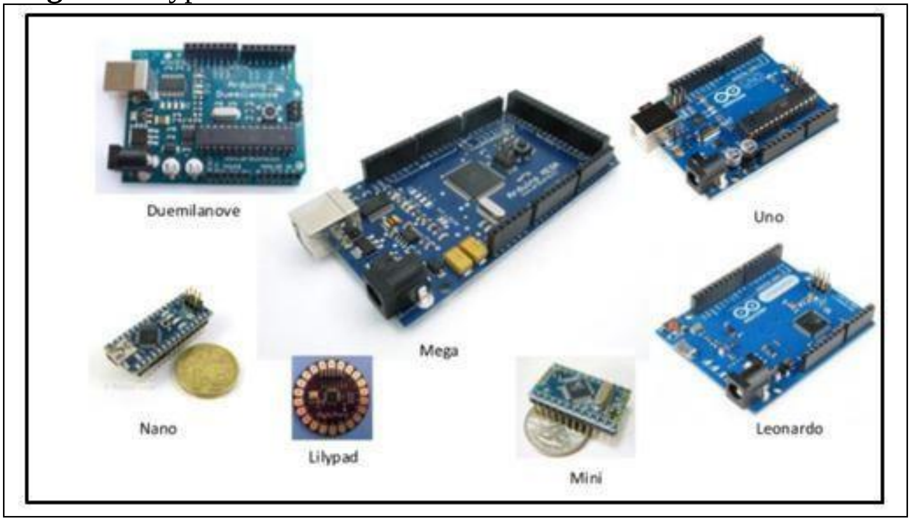
Source: http://www.rfid.ind.br.

3.1 Arduino

Arduino was developed in 2005 with the aim of creating a platform for the simple and uncomplicated development of interactive projects using a microcontroller. It is part of what is known as physical computing, which is the area of computing where software interacts directly with hardware, making possible easy integration with sensors, motors and other electronic devices.

Technically, the Arduino board can be defined as a small computer that can be programmed to process inputs and outputs between the device and the external components connected to it (McRoberts, 2011; Dhatri et al., 2019; Valsan et al., 2020). Arduino is a non-proprietary programming platform, especially useful for the development of projects involving sensor modules or for general use in practices aimed at teaching experimental physics (Souza, 2011; Cavalcante et al., 2011).

Figure 5. Types of Arduino.



Source: https://pt.slideshare.net.

The microcontroller can be understood as the incorporation of a microprocessor (and timing, acquisition and communication systems) in the same integrated circuit. And an example of a development platform, based on microcontroller, widely used today is the Arduino. As shown in Figure 5, there are several types of Arduino on the market, one for each type of application and need.

3.2 GSM networks

Global System for Mobile Communications (GSM) is a communication protocol for wireless devices, developed in 1982, aimed at homogenizing the communication technologies used in European countries that were previously purely national. In 1992, however, the technology, which was already in operation in some parts of Europe and the United States, aroused international interest (Heine, 1999).

One of the main benefits of the GSM network is the possibility of using the SIM Card, where the information is contained on the chip. From there, it can then be removed and connected to another cellular device using the same or another GSM network from another country, for example, without having to change the phone number, taking only the card. Figure 6 shows the flow of operation of a GSM network up to the moment of delivery of the voice packet.

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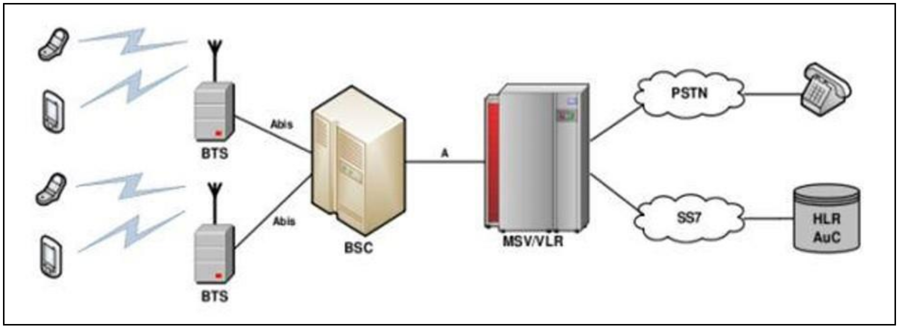
Figure 6. Basic components of a GSM network.

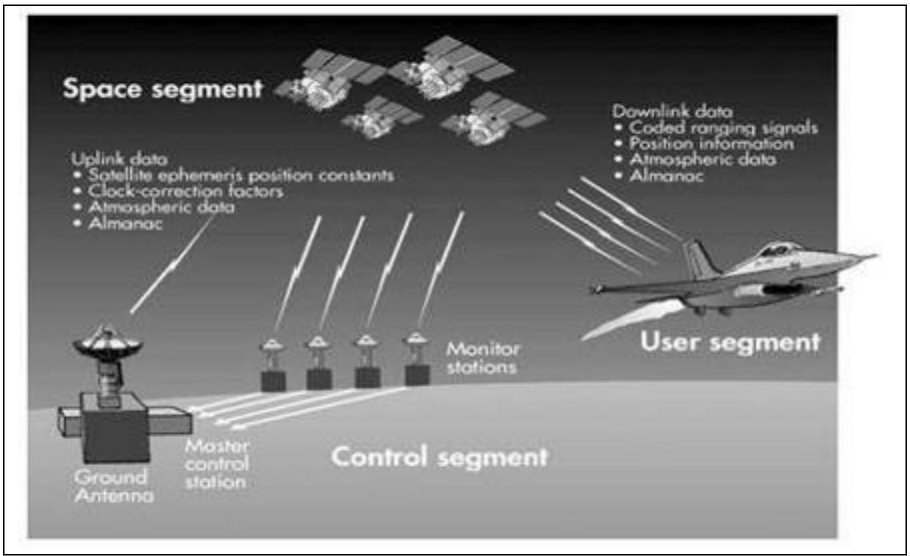


Source: https://static.vivaolinux.com.br.

3.3 GPS

According to Monico (2000), the Global Positioning System (GPS) is a radio navigation system developed by the Department of Defense of the United States of America with the intention of being the main navigation system of the American armed forces. This technology resulted from the merger of two programs financed by the US government to develop a navigation system with global coverage: Timetion and System 621B, under the responsibility of the Navy and the Air Force, respectively. Due to the high precision provided by the system and the great development of the technology involved in GPS receivers, a large user community emerged from the most varied segments of the civilian community (navigation, agriculture and fleet control). GPS are basically divided into three distinct segments, as shown in Figure 7.

Figure 7. Types of GPS.



Source: https://camo.githubusercontent.com.

The Global Positioning System, better known as GPS, is a navigation system based on the use of satellites. The use of this positioning system for civilians is partially open. The accuracy of position, speed and time information depends on several factors, including the receiver, climatic conditions and geographic location.

The space segment can be understood as an aerial segment composed of 24 satellites, which are distributed in 6 distinct orbits. It was designed so that anywhere in the world and at any time there are at least four GPS satellites above the observer's horizon. The control segment consists of 5 satellite tracking stations. These stations coordinate all systems, determining the orbits of all satellites and have as main tasks to continuously maintain and control the satellite system, control GPS time, calculate the correction of satellite clocks and periodically update their navigation messages. The user segment is made up of any individual who owns a GPS receiver. These receivers can decode radio signals emitted by GPS satellites. This segment includes all applications: carriers and codes, set of system users and various types of receivers.

4. Results and Discussion

As the objective of this study was to design a portable product delivery tracking system, the first challenge was to adapt all components in a single device that could be transported by the person in charge of delivery. This challenge was overcome with the use of a plastic suitcase, which had enough space for the installation of the components and provided practicality for its transport. To make the device more interactive, the LCD display was used as an interface between the system and the delivery person, as shown in Figure 8.

Figure 8. LCD display.

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A point that should be improved in this prototype, in a future work, is to increase the distance between the portable collector and the RFID tags, so that the proper communications are established. In this work, the distance was limited to 10 mm (maximum range of the RFID tag used) for this communication. This would be a problem for more robust systems, such as portals installed on box trucks.

During the tests, it was found that the information “Data Collected Successfully” was displayed on the LCD display, after the reading of the LCD label by the collector. For testing the sending of date, time, product specifications and location information via SMS to the registered cell phone at the time of product delivery, operations were carried out in different locations with different dates and times, and the messages were sent without fail.

Table 1. Project costs (values in R $ in December 2017).

Costing items	Cost (in Real R$)
Arduino Mega	65,00
Module Sim900	135,00
Shield GPS Neo 6m	85,00
Kit RFID 13.56MHz	35,00
Display LCD 16x2	20,00
Plastic box	10,00
Kit Jumper MF	10,00
Total	360,00

Source: Created by the authors.

Regarding the costs for making the prototype, the costing items are shown in table 1. The total cost added up to R $ 360.00. Considering the average dollar value in 2017 (R $ 3.30) in relation to the real, the total investment cost was U $ 120.00. If it were produced in series, these costs would probably be further reduced, which demonstrates the highly competitive potential of the technology generated.

5. Final Considerations

This study presented a device for traceability of the goods delivery process, using radio frequency technology (RFID). The proposed prototype proved to be effective for its purpose of controlling the delivery of low-cost goods through passive tags and a portable RFID reader. The purpose was to automate the delivery process at the time of the goods leaving the truck, informing the central the date, time and location in real time of delivery of the goods. As a suggestion for future work, we propose a study of the implementation of an RFID reader and RFID tags with a greater communication range, allowing the process to be executed automatically over a long distance and enabling the application of this system in more robust processes.

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