Technical Feasibility Study of IoT Tag for Identifying and Monitoring Sensitive goods in Logistics Systems

Abstract:
A problem that supply chain systems face, when moving sensitive goods, is to ensure the integrity of the products along a complex chain of routes and multimodal transport systems. Sensitive goods are products that are susceptible to large variations in temperature or impacts and mechanical vibrations, and that have high added value. These goods are monitored through tags, which contain a numeric code associated with the package, and the electronic form of this procedure is widely used through tags containing RFID devices technology. The purpose of this work is to study the technical feasibility of implementing an electronic IoT tag system, which in addition to identifying the merchandise still can continuously monitor temperature variations and mechanical impact, generating a log that is automatically transmitted to the management system of the supply chain reporting these occurrences.

Keywords: Active Tag, Sensor, Supply Chain, IoT, Arduino.

1 Introduction
The National Confederation of Industry (CNI) study points out that Brazil invests only 2.18% of its Gross Domestic Product (PIB) in infrastructure, in contrast to the other emerging economies that invest between 4 and 5% of their PIB in this sector (e-commercebrasil, 2019). In this same scenario, the agribusiness sector is expanding. the situation presents a challenge to the country's logistics sector, which depends on a solid infrastructure for freight displacement operations, which represent 30% to 70% of supply chains (e-commercebrasil, 2019).
In this way, logistics companies need to optimize their information systems so that they can have greater control in the transportation of freight and identify possible problems in a more agile way, allowing greater efficiency in logistics. One of the important tools to have this control is the correct identification of the volumes in a freight, regarding their content, making it possible to have control of the displacement of these volumes in multimodal routes.
The use of identifiers, known as TAGs, of the electronic type, has advantages of ease of reading and quality of identification, with the use of electronic tag readers (Xiaolin at al, 2012). This type of technology makes use of radio waves. Two technologies are most used for this purpose, which is the SemiPassive UHF tag, and the Active tag. The first has the advantage of being a cheap device, small in size, and reliable, but it is a short-range identification (in the order of 10 meters). The most used semi-passive technology is radio frequency identification (RFID). Active tag technology has a range of hundreds of meters and can monitor the load with the use of electronic sensors, but it requires more sensitive, bulky, and expensive equipment. RFID devices also do not have internal memory, which makes it impossible to generate a log, which is possible with Active tags, as they have memory.
Log generation is a very useful tool in identifying any problems along the logistics route. This work aims to identify and suggest an electronic tag architecture that meets the load

identification, recording critical events, and monitoring this information, maintaining the characteristics of low cost and ease of use, through IoT technology.

2 Methodology

To achieve the objective proposed in this work, the types of technologies used in the identification and monitoring of goods in logistics systems were studied, understand their advantages and disadvantages, with a focus on point technologies that meet the specifications defined for the project, which are:

a) Low cost;
b) Small dimensions;
c) Ease of identifying electronically the goods;
d) Ability to monitor critical events for the goods;
e) Data storage and traceability of these events.

There are three types of technologies used in electronic tags, passive, semi-passive, and active. Passive tag technology is aimed at commercial establishments, in the identification of individual products, such as clothing and food items. These tags are the cheapest and are intended to control local inventory and prevent theft of the product, so this type of tag will not be addressed in this work. Therefore, the characteristics and possibilities of the other two technologies used in electronic tags were identified and described below.

2.1 Semipassive tag

This technology consists of an electronic device composed of a transceiver (with decoder), a transponder programmed with unique information, and an antenna, inserted inside the label, without batteries. When it receives a radio signal in the UHF band, generated by the reading device, that device responds with a numeric code associated with the identification of the goods. The energy of the interrogation signal of the RFID reader captured by the antenna of the electronic tag is used to drive the circuit of this and relay with the numeric code (Xiaolin at al., 2012: 153). This architecture allows the electronic tag to have very small dimensions, robust construction, and simplicity of operation, however, the communication range for reading is very reduced. There is the possibility of extending this reach a little more through more powerful reading devices and the use of high-performance antennas, requiring specific installations for this system. Due to the very low cost, in the order of ten cents of a dollar, this type of electronic tag is widespread in supply chain systems. As a consequence of the electronic simplicity of RFID, and because it does not have energy storage, it is not possible to maintain monitoring through electronic sensors and store this information. This tag is limited to goods identification only. In Figure 1 is presented a schematic representation of an RFID system.

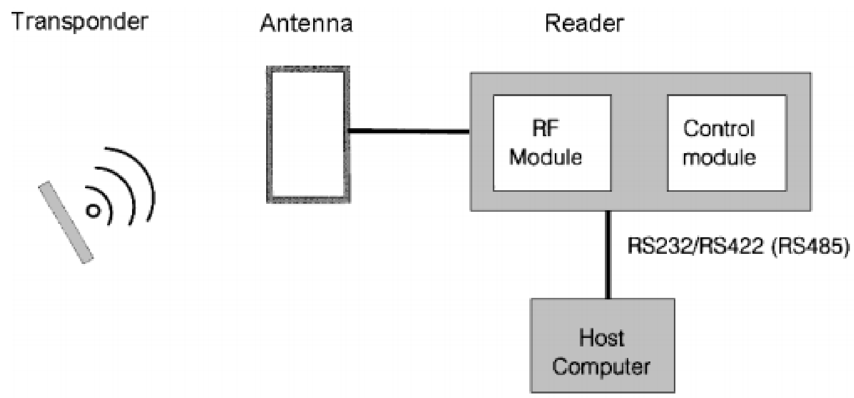

Figure 1 - Schematic representation of an RFID system.

Source: (M.Kaur at al., 2011: 153)

2.2 Active tag

Active electronic tags have, like passive tags, an electronic part and antenna, but additionally, they also have a way to store energy, usually batteries. With the availability of full-time power, these tags can have more sophisticated processors, with the ability to read sensors and store this information. This allows the implementation of a data logger system, very useful in monitoring sensitive goods. This type of functionality allows us to identify whether the merchandise has suffered any type of physical impact, exposure to dangerous temperatures, unauthorized opening of the packaging, among others. The possibility of reading sensors allows monitoring by this type of temperature, humidity, door status, vibration, motion, radiation, chemical or biological tag, and store these readings in a datalog (M. A. Kossel, 1999: 2242). This technology uses reading devices based on special transceivers, which enable communication with the tags, allowing their reading. The use of special equipment rises the system cost. However, this architecture demands the use of full-time energy, requiring the use of batteries, increasing weight, and size.

2.3 Project Proposal

The purpose of this work is to study the feasibility of an economically viable alternative to electronic identification for the supply chain with the ability to identify and monitor sensitive goods, storing an access log to allow the identification of the location and type of risk suffered by the goods. The proposal is to use the IoT philosophy as a way to cheapen and simplify the package tracking structure. This work intends to adopt concepts used in wearable devices. This term defines technological devices that can be used as garments. So some concepts can be used, which must have small dimensions, high resistance, and the ability to transmit complex information, in addition to the solutions related to their energy system.

The suggested architecture system to support project requests must be able to read, process, and store information from electronic sensors, in addition to transmitting them when requested or when appropriate. For this, the tag must be based on a microprocessor with the necessary performance for this function, combined with low consumption, a transceiver, electronic sensors, and an energy storage system.

The proposed tag should meet most of the possible scenarios for the movement of sensitive goods normally encountered by the supply chain. Sensitive cargo means goods sensitive to physical impacts, such as delicate electronic devices, and goods sensitive to temperature variations, such as medicines and vaccines. Also, a light sensor will be incorporated to identify possible unauthorized openings of the packaging that pack the goods.

The differential of this study is that this electronic tag communicates with the wifi structures along its displacement route to periodically communicate situations of risk to goods or unauthorized openings of the package. The tag will transmit, whenever requested, given ID. Additionally, a cargo manifest can be loaded into the tag's memory to streamline the checking of its content. The tag can be read by devices with wifi capabilities, such as smartphones, tablets, or notebooks, just install the appropriate app on the device. The verification at the checkpoints will be done identically to the use of semi-active tags, with the difference that wifi access routers will be used. This strategy lowers the cost of operation and maintenance related to tag readers and allows checks in locations outside the supply chain that have wifi structure, such as public networks.

Anytime the tag finds an enabled wifi network, automatic identification transmission, sensor logging, and tampering, impact, and temperature alarms can occur.

3. System Architecture

To perform the proposed function, the electronic tag must be structured with the following systems:

Microprocessor system: This system must support the necessary processing and have adequate storage capacity, in addition to having a low cost, small dimensions, low energy consumption, and low weight. There are currently several commercially available microprocessor-based development platforms, such as the Arduino family, Raspberry Pi, and BeagleBone. These platforms have a wide variety of low-cost sensors specially developed for them, in addition to compatibility with numerous other commercial sensors. The main challenges are to integrate the data of these systems in this kind of microprocessor platform and develop modular software application of operational control of the system (S. Monk, 2015: 11). This platform can be used as a node sensor (S. Ferdoush, 2014; 103) enabling data communications (K. I. K. Wang at al., 2016). Due to the low cost, low consumption, reduced dimensions, and a built-in analog / digital converter, this work proposes the Arduino Uno shield as the base of this tag's microprocessor system.

Sensors system: This system contains sensors that will read the environmental parameters that we want to monitor. To assess the physical impacts suffered by the packaging of the goods, a three-axis inertial sensor module will be used, which allows the evaluation of the impact force from any direction and mechanical vibrations. To measure the air temperature inside the package, a sensor based on an NTC type semiconductor device will be used, which is cheap and very reliable. Finally, to identify unauthorized openings of the packaging, a sensor based on an LDR semiconductor device will be used, in common use, good precision, and inexpensive.

Transceiver System: The transmission system defined for this work is that of wifi. This protocol is not the most appropriate for use in electronic tags in terms of performance and energy consumption, however, the use of this protocol makes communication with the tag much more flexible and makes the equipment for reading the tags cheaper. Wi-Fi is a common name of Wireless Local Area Network (WLAN) whose standard was defined by the Institute of Electrical and Electronics Engineers (IEEE). The Family of 802.11 standards is one of the most popular technologies of wireless communication (M. Wcislik at al., 2015: 312).

Energy System: This system is challenging in this type of application where low weight and high durability are important. There is a need to choose a type of energy source that combines low weight with high energy density. A classic solution is the use of ion batteries high-performance lithium. There are batteries of this type specially designed to occupy the minimum space, presenting small thickness. These types of batteries are sensitive to impacts and high humidity, and explosions can occur in case of damage. However, the intrinsic use of the tag, stored in a controlled environment, reduces this kind of risk. Another possibility is the use of supercapacitors, which combine small dimensions with a very high energy density. The limitation of this type of device is how much voltage it can offer, in the order of three volts. However, devices such as electronic tags work with low voltages.

Considering these systems, the architecture of an electronic tag is presented in Figure 2.

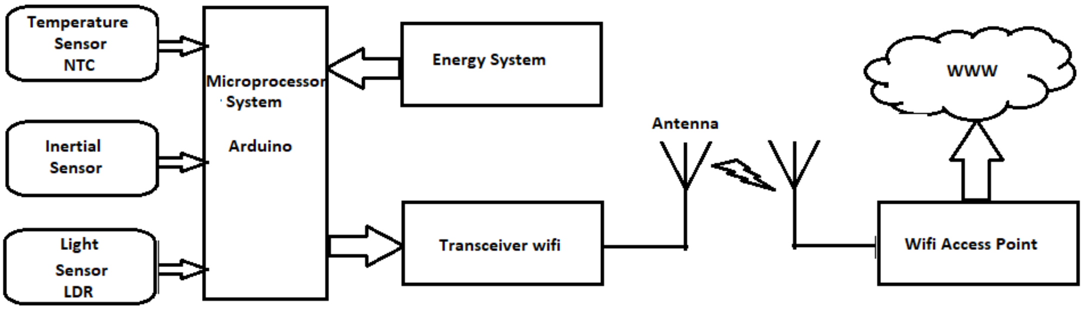

Figure 2: Architecture of an electronic tag
Source: Author

The objective of this work is to add value to the control of supply chains, optimizing the monitoring of the movement of sensitive goods. The electronic tag idealized by this study suggests to use the IoT philosophy to increase the level of security in the movement of sensitive goods without increasing the cost of the necessary equipment. The strategy for this was the use of a communication protocol that was not optimized for this operation, but that presents advantages in its implementation. The use of the wifi protocol adds flexibility in the use of tag reading equipment while expanding the possibility of communicating it with the use of public networks. The range of the wifi protocol can reach 100 meters, using more powerful access equipment, very close to the reach of traditional active systems. However, this protocol represents a challenge in terms of energy consumption, which is higher than that of other protocols developed for this application. To minimize this, it is necessary to use a low-consumption microprocessor, such as the Arduino, and to define a low-weight and small-sized energy source, but with a high energy density, which points to the use of supercapacitors. Also, the possibility of monitoring the occurrence of impacts on the packaging, or of temperatures that exceed the limits for packaging the goods, in addition to the possibility of identifying unauthorized openings of the package, in addition to the ability to transmit logs and alarms automatically, increases the level of monitoring of the merchandise

4 Conclusions

The use of a wifi communication protocol in electronic tags for the identification and monitoring of sensitive goods is a possibility since the possibility of recording a log of risk events to the goods and of transmitting them automatically using a network of widespread use not only in a supply chain environment, combined with the flexibility and cost reduction that the use of this technology presupposes, compensates for the greater use of energy that would compromise the autonomy of the device, therefore, the technical viability of this concept is valid, suggesting the development of a prototype to test the technologies involved and confirm the economic viability of this electronic tag architecture system. Energy storage strategies and the use of low consumption devices should be further researched.

5 References

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