AVL System Integration with RFID for the optimization of Cargo Transportation

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Abstract: - The aim of this paper is to describe and evaluate the integration of different technologies such as RFID, in order to improve road transport and distribution of cargo, resulting in a decrease or even mitigation of damages involved in current logistics processes.
The advantage of using AVL integrated with RFID technology is shown by comparing with the current model of the logistics process for supply of goods, which can be seen the greatly simplify and security achieved.

Keywords: - AVL, RFID, logistic process, fractioned cargo

1 Introduction

The supply chain is gaining focus and attention of executives in today's competitive world, and increasingly they are turning attention to increasing efficiency and reducing costs. This challenge combined with the need to deliver products on time and in the desired location is making companies to invest more in new technologies. Globalization opens up space for companies to participate and compete in markets little explored, like the case of companies specializing in logistics operations.

2 Technologies

Among the new Technologies, are there developed to meet the demands of Supply Chain, as the WMS - Warehouse Management System, routers (software that show the best alternative route for deliveries), the system AVL - Automatic Vehicle Location, beyond the software used to minimize losses and reduce failures in delivery of goods. The technology is something important in the chain of Supply Chain Management, which gained even more highlight with the advent in the market for RFID tags. These smart tags use radio frequency to identify products. The name given to it is Radio Frequency Identification, often referred as RFID. Though its functions like the Barcode, widely used in distribution centers of companies, and be considered a technological advance, is increasingly proving that these smart tags tend to be complementary to the barcode, however, something that would revolutionize the management of the supply chain, providing information in real time.

2.1 AVL

It is the name given to communication and positioning systems that allow the knowledge of the vehicle position and realize associated procedures. AVL it's not a technology, but a concept of using technology. Several different technologies can be used together as each application, with the objective of providing to the user a tool to support the implementation of a series of activities related to transportation. These activities range from the simple tracking of a vehicle for security purposes, such as tracking of large fleets to a logistics control. Knowing the position of the vehicle as well as other information collected about their condition, and state of cargo possible to carry out a series of operations, such as monitoring and tracking, logistics control, risk control, fleet management, among others.

2.1.1 AVL System Components

The AVL system is basically composed by the system of data acquisition, communications systems and the system of information management, which are described in items 2.1.1.1, 2.1.1.2 and 2.1.1.3. In item 2.1.1.4, is described in detail the proposal for a different approach for the use of AVL in order to

complement the existing systems. Figure 1 below shows the components of an AVL system.

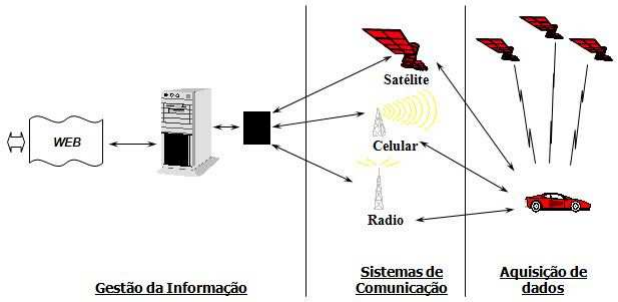

Fig.1: AVL System Components (Source: Reference [10])

2.1.1.1 Data Acquisition

According to [10], vehicles onboard equipments acquire data about:
- The vehicle position, where devices are used to acquire data from satellites located around the globe;
- The vehicle state is acquired through sensors installed on the same, for example, door opening sensors, sensors to check the vehicle physical condition, such as operating temperature, oil pressure etc..

The media are dependent upon characteristics of each operation. Examples of media, we can mention:
-Text messaging;
- Voice communication;
- Data transfer.

2.1.1.2 Communications systems

These technologies transmit and receive data between a central office and the vehicle. The technologies used for communication are:
- Via phone;
- Via Satellite;
- Via radio.

The main advantage of using exchange data via cell phones is the high speed data transmission at low prices, unlike satellites that despite high rates of data transmission, the cost of transmission is very high compared with other technologies. The radio transmission, although no cost data transmission, transmits the data in very low rates. Thus the use of mobile telephony is the dominant technology in AVL systems.

2.1.1.3 Information management

Are systems that perform the management of collected data, analyzing the processes associated with the vehicle travel, turning into information and giving functionality to the system, and managing the sending and receiving data.

2.1.1.4 Different approach of AVL use

The reference [11] proposes a different approach from the current AVL system with the objective of complementing the existing systems. The following will describe in detail the approach proposed by reference [11].

According to reference [11], the main problems found in some AVL systems are:
- High cost for data transmission via satellite, as mentioned previously;
- In data transmission via radio, the coverage area is limited, necessitating the construction of repeater stations;
- High cost for data transmission in the conventional way, via cell phones. In the case of data transmission via GPRS, the connection is limited by the infrastructure operator;
- Possibility of discontinuation of the manufacture of hardware.
-Do not operate the GPS indoors;
- Low accuracy in tracking ground antennas using triangulation;
- The Cell-ID has very low accuracy for the routes representation;
- In central monitoring, the software license cost is high, when the use of free software is found difficulty in configuration and installation;
- The cartographic databases used for monitoring are often incomplete and without precision.

In [11], were tried to prioritize the following:
- Lower operating cost;
- Use equipment that have hardware warranty;
- Quality of the representation of routes;
- Use of monitoring tools free.

The Fig. 2 represents the proposed system by [11].

This system uses the following technologies:
- GPRS data network, available on most roads in the state of Sao Paulo, the user fee is charged per megabyte downloaded and not by connection time, and a variety of hardware available on the market compatible with GPRS;

- GPS positioning system, which offers quality in determining the location, offers no cost to use, global footprint and low cost and wide variety of options on the market;
- Central monitoring, which uses the Internet to give access to and monitoring system for communicating with mobile units.

The monitoring system proposed by [11] was web, as shown in the Fig. 3, which indicates the route made by a particular vehicle at a given time.

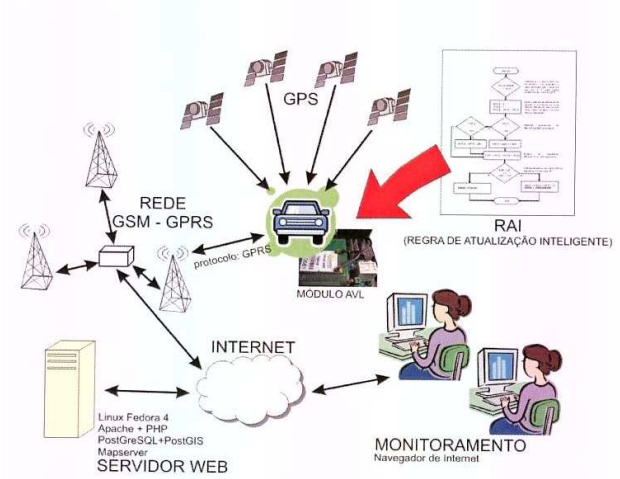

Fig.2: AVL System proposed by [11]

Fig.3: AVL system proposed by [11]

2.2 RFID

The electronic tags work from an electromagnetic field where waves at certain frequencies can transmit information without the need of wires (wireless) and the tags are within a radius of vision or action of any person. To transmit information via electromagnetic waves, RFID tags consist of a small chip, also known as integrated circuit, where it is stored the EPC - Electronic Product Code and other possible information, and an antenna to capture the waves.

The radio frequency identification is essentially in electronic devices (tags) passive or active that are programmed with information and attached to objects that need to be identified or tracked, such as trucks, vehicles, cash and units.

The cost of active tag are larger than the passive tag, besides having a limited shelf life. Passive tags operate without a battery, and its power is supplied by the reader via electromagnetic waves. This type of tag is cheaper and has theoretically unlimited life. Can be either read or read / write, used for short distances and require a reader with more power.

To illustrate, the following is examples of RFID tags.


Fig.4: RFID Alien Squiqqle Tag (Source: Reference [13])


Fig.5: RFID Alien “M” Tag (Source: Reference [13])


Fig.6: RFID Philips I Code Label (Source: Reference [13])

Other devices that make up an RFID system are basically:

- **Antenna:** component that generates the magnetic field that activates the tag and sends information to the reader;
- **Reader:** get the information captured from the tag, decoding them and make them available to software. The Fig. 7 and Fig. 8 are two examples of RFID readers;
- **Software:** receives the decoded information of the reader and makes the interface with the company's transactional systems.

Fig.7: RFID reader (Source: Reference [13])

Fig.8: RFID reader (Source: Reference [14])

The RFID can be generated through a printer as the Fig. 9 example.

Fig.9: RFID Printer (Source: Reference [13])

2.2.1 Advantages

- Durability;
- Autonomy;
- Ability to store information;
- Na RFID reader can read multiple tags quickly;
- RFID tags can be read at greater distances, and can read products that are not in your visual range.

2.2.2 Disadvantages

- High initial cost;
- The RFID readers may fail to read the tags for several reasons: distance and orientation of the tags for the reader, materials such as metals or liquids may distort or absorb the signal from the RFID tag, electromagnetic waves, background noise generated by other equipment and the speed with which the tags move through the readers.

2.2.3 Exemples of RFID use

a) Control of access to a residential condominium

According to [6], a condominium in Southern California, United States, implemented a system for identifying vehicles from RFID tags to replace manual control of entry and exit fees, hoping to increase security and enforce parking privileges in the condominium. The system works as follows: each vehicle condominium has an RFID tag affixed to the windshield, so approaching the gate of the condominium, a receiver reads the tag and passes the id corresponding to the system access control neighborhood, which checks in your database is a valid id in the condominium, if there is, the gate opens automatically.

The Fig. 10 shows the implementation of the system.

Fig.10: RFID used in condominiuns (Source: Reference [6])

b) Monitoring Traffic

The Society of Traffic Engineering of São Paulo, CET, according to [7], began deploying in 2006, RFID chips in taxis, car fleet CET and some school buses and chartered by the city of Sao Paulo, and also put receiving antennas on some roads. The objective is to monitor congestion in the city, so that receiving antennas

receive offset information of the chips and send them to the central traffic management, thus the system can calculate the average velocity of vehicles on the avenue analyzed can measure the degree of congestion of the road. The traffic information is made available to the public through the website of the CET, updated every 5 minutes, and also on electronic billboards around town, and they are passed on to radios and newspapers. The Fig. 11 shows the traffic at a known São Paulo avenue.

Fig.11: RFID used in traffic monitoring (Source: Reference [9])

c) Stock control and delivery

According to [8], a furniture and appliances store, Casas Bahia, has implemented a pilot project for stock control of some products in its distribution center in Jundiai, Sao Paulo. In this case, some products have received the RFID tag and receiver units were installed inside the warehouse. They receive information from RFID tags at a distance of up to three meters, and transmit to an intermediate system, and follow the system's management company, where concentrated amounts of information products that enter and exit the stock, them and their location within the stock.

Fig.12: RFID used in Casas Bahia stock (Source: Reference [8])

d) Companies and organizations inventory of assets

Depending on the size of a company, the inventory of assets is a job that can take months and involve more than one employee, however, according to [8], with the use of RFID has been facilitated, as an example of implementation in the Banco do Brasil. In this case, RFID chips have been attached to property belonging to the bank, such as boards, computers and other equipment. Were arranged four receiving antennas that collect RFID information from equipment such as the identification code of asset, and send to the servers dedicated for the application, which will be integrated into the inventory system database. Thus, it is possible to know instantly if the equipment is in place for use, maintenance or will return.

e) Obtainig information of the good in retail

According to [8], the supermarket Pão de Açúcar installed in his cellar in the Iguatemi Shopping, RFID tags on every wine sold, then when the customer get near the query terminal, even with wine inside the shopping cart, and he have all the wine information, such as price, type of grape, the winemaking region, producer, foods that combine with the wine, among others. The information is presented when the antenna of the query terminal captures the identification of wine through the RFID tag, sends via Wi-Fi to the server that contains a database of product information, and displays the customer.


Fig.13: RFID used in Pão de Açúcar cellar (Source: Reference [12])

2.3 Barcode

It consists of a graphical representation consisting of parallel dark bars with various thicknesses, printed on a surface by spacing determined by standardized

technical specifications of each type of code. To illustrate, then a barcode is presented.
The Fig. 14 shows a barcode example.

Fig.14: Barcode example (Source: Reference [13])

Its main function is the data acquisition to manage the automated entry of information into a computer system, where a reading device (scanner) realize, through an optical process, a barcode scanning, capturing signals by launching a beam of light and reflection of radiation by white space. The optical scanner converts the light information into digital data compatible with a computer language to be able to verify the validation of symbols (form in which encodes information on the bars and spaces of the symbol).
Where the bar is dark, the light is absorbed, and where the bar is clear (spaces) the light is reflected back to the scanner recognizes the data that are represented there. There are numerous symbols currently used commercially, among the most popular stand out UPC - Universal Product Code, EAN - European Article Numbering and Code 39. UPC and EAN codes are international systems that aid in unambiguous identification of an item being sold, moved and stored. The most known and used worldwide is the EAN-13. The numerical structure of the code, which usually stays below the bars represents the following information, for example: 7898357417892 where the first three digits represent the prefix of the organization responsible for controlling and licensing the numbering of the country where 789 represents the GS1 BRAZIL - Brazilian Association of Automation. The next digits that can vary from 4 to 7 represent the identification of industry owns the brand product in the above example is the 835,741 (6 digits). The digits 789 represent the product identification industry and determined by the last digit (2) is called a check digit that helps the safety of reading. In total, EAN-13 code should be 13 digits. It is noteworthy that the firm's numbers vary from company to company, the numbers that identify the item vary from item to item and the check digit must be recalculated every variation in numbers There are other kinds of code patterns for different applications.

2.3.1 Advantages
- Low operating cost;
- Widely used worldwide;
- Standardization world;
- Low maintenance.

2.3.2 Disadvantages
- Failure compromise the print reading;
- Reading performed only by approximation;
- Subject to damage.

2.4 RFID versus Barcode
According to [13], the barcode should not have a promising future, because as most retailers are using software WMS (Wharehouse Management System) and TMS (Transportation Management System), the item 2.4.1 and 2.4.2, respectively, brings more information about these systems, and these have interactions with RFID, the migration of barcode to RFID is very positive for the sector, but what is delaying this migration is the high cost of RFID over the barcode, which costs around U.S. $ 0.50 stamp, while the barcode costs about the amount of ink spent to print it.
The cost of RFID is not representative when used for the identification of products of high added value, unlike the barcode.

Comparative table between technologies			
	Barcode	**Passive RFID**	**Active RFID**
Reusable tag	no	yes	yes
Modifiable data	no	yes	yes
Information capacity	until 30 bits	until 64 kB	until 8 MB
Tag cost	insignificant	US$ 0,50	until US$ 100,00
Equipments cost	low	high	too high
Standardization	defined	under definition	under definition
Durability	small	undefined	3 until 5 years
Reader distance	15 until 30 cm	until 25cm	more then 100m

Table 1: Comparative between RFID and Barcode (Source: Reference [13])

The barcode in turn, has well defined standards and accepted worldwide, which does not occur with RFID, since it can operate in four different frequencies and there is a need for worldwide standardization.
RFID has a very interesting feature, which is the

possibility of reading multiple tags at the same time in distances over 100 meters, even existing physical barriers along the way, which facilitates various operations in different areas of activity. The Table 1 is a comparison table between the barcode and active tags and passive RFID.

2.4.1 Wharehouse Management System

According to [17], until the late 70s, the inventory control of goods in the warehouses was done only for the entry and exit of goods, having no control on where the goods was within the warehouse, being impossible to optimize warehouse space and location of goods.

Fig.15: Warehouse implemented with WMS (Source: Reference [19])

In this sense, stock management methods begin to be developed, where each goods had it location within the warehouse, facilitating the goods location as well as the warehouse space optimization.
Nowadays, is used the WMS, whose main aims are controlling the storage and movement of goods within the warehouse that involve many process like shipping, receiving, put away and picking.
Accordingly to reference [18], the WMS uses many technologies to locate and monitoring the goods flux within the warehouse, such as barcode, mobile devices, local area wireless network and possibly RFID. The data collected at warehouse are then compared with the data disposed at a central database, enabling the total control of the status of the goods at the warehouse.
The advantages of the use of WMS are:
- Optimization of the goods location;
- Optimization of the warehouse space utilization;
- Productivity improvement;
- Time and costs saving.

The Fig. 15 shows a warehouse implemented with WMS.

2.4.1 Transportation Management System

According [16], TMS or Transportation Management System is a software that looks for the warranty and productive of the distribution process of goods. This system is developed in modules that a client has to purchase the appropriate modules for his operation.
The role of TMS is the control of the cost of any element associated to the transportation process, as follows the examples: cargo control, human resources, freight tables, fleet maintenance cost etc. With the control of these costs, the software presents the best model to use, with the objective of cost minimization and also allows prevent possible problems with the electrical and mechanical parts of the fleet vehicles.
So, TMS is a solution for three types of companies: transportation companies, like logistics and carriers, companies that use their own transportation to support your business and companies that use third-party transport.

3 Transport of Road cargo

When a shipper requesting the service of a carrier to dispatch a consignment of goods and bring it up to a specified destination, their expectations can be summarized to have the application actually delivered to the recipient, without damage and without loss, on time and through the combined payment of a reasonable freight. For the carrier, the issue is more complex. Even considering the transport of traditional cargo, yet devoid of logistics services today quite frequent, the operations of carriers have different characteristics, which vary depending on the amount and type of cargo, offset distance etc.
In general, companies provide road cargo transportation basically four types of services.

3.1 Transport stocking complete

The charge is collected on the premises of the shipper; is carried in the same vehicle, for the recipient warehouse, without going through the deposits of the carrier. This type of service occurs when there is enough cargo to fill a vehicle is not necessary to use the carrier's terminal for cargo handling.

3.2 Services of local fractional cargo

The cargo is collected at the shipper's premises and moved to the warehouse of the carrier. It made the sorting and transfer to the delivery vehicles, which make deliveries directly to recipients located in various parts of the same city, or in other nearby towns. In this case, the deposit used is only local carrier.

3.3 Long-distance services of fractional cargo

Similar to previous, but occurs more an unloading/sorting/loading in a warehouse's regional carrier. This additional intermediate stage is necessary to ensure that goods are again separated by delivery route and reloaded in local vehicles. In this case, the regional terminal receives goods over the country. It is made then the unloading of goods coming from various regions, and again separated by route and reloaded in delivery vehicles, usually minor.

3.4 Long-distance services of fractional cargo with intermediate terminals

Equal to the previous case, but with the existence of intermediate terminals of the carrier, to rearrange the packages from the transport corridor.

4 Difficult of transporting fractioned cargos

Many carriers are facing problems in fractional distribution of goods. There are in most cases human failure, that generate extra costs related to cargo resent that was mistakenly changed for example. This is aggravated by the type of cargo and distance to the point of delivery.

The Fig. 16 shows the actual delivery process of goods that is causing inconvenience and extras costs.

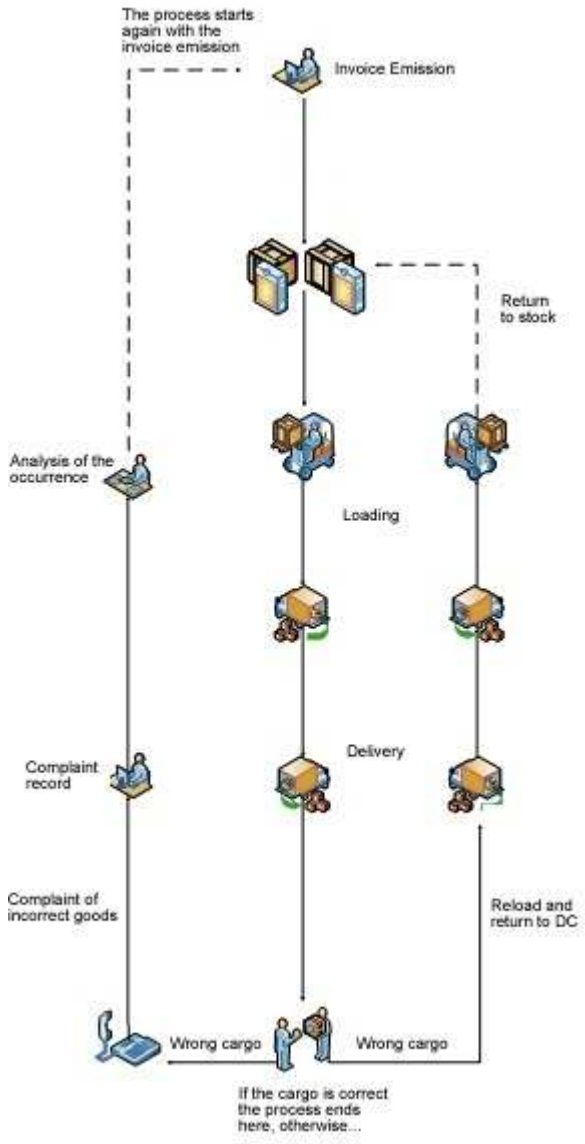

Fig.16: Fault process creates inconvenience and extra costs

5 Proposal of application of the RFID technology

The use of smart tags in conjunction with the tracking systems would assist in the processes of transportation and distribution of fractioned cargo.

The proposed model predicts that after the separation and assembly of the delivery route, RFID tags were glued to each product before loading for delivery, replacing the current barcode. The data of all products loaded into a truck would be constantly read by a system on board, through antennas installed in the cargo compartment, and compared to the data of the distribution center.

Combined with the georeferenced deliveries script, a load of registered products would be able to leave the distribution center and each delivery would be specific to a pre-registered geographical point.

The Fig. 17 shows the proposed delivery process of goods, where costs and time are saved.

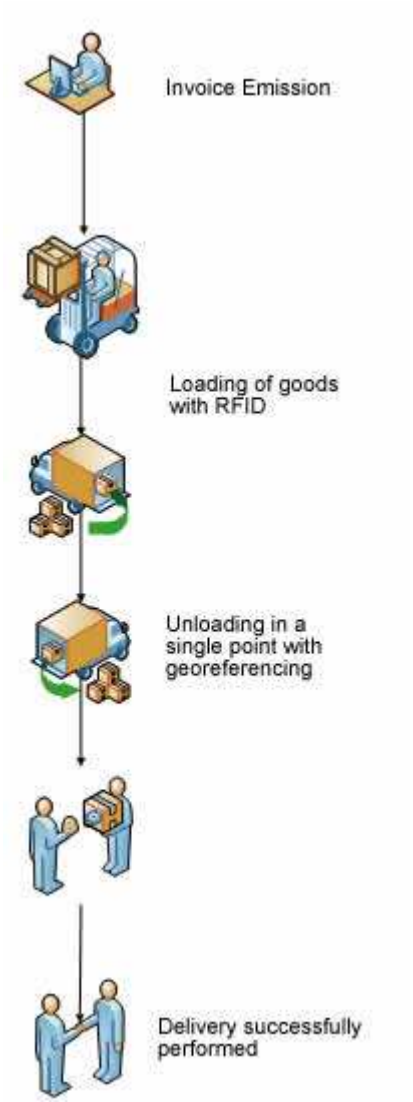

Fig.17: Process with smart tags

6 Conclusion

With the introduction of the technology of RFID tags for some years ago, the process of replacement of existing barcodes to identify products and goods has been evolving gradually. The fact is that both methods have revolutionized the process of storage, distribution and marketing of goods.
The proposal presented in this article, by placing RFID tags on products to be transported, is a point to be addressed, because in the future these products will leave the factory with such smart tags containing data from the manufacturer, and being able to be written with information from other resellers.
But today many companies raise points that should be addressed and analyzed to predict the future of RFID technology, among them the invasion of privacy.
The model of integration of these tags in today's AVL systems, already used by many carriers, provides benefits such as agility and efficiency, reduction in failure rates and consequently reduction in spending generated extraordinary.

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