Ubiquitous System to Enhance the Supply Chain

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***Abstract*—Transportation and logistics include delivery, movement and collection of goods through roads, and in the international case also through ports and airports. Consequently, they usually involve many different actors, what complicates management, reducing efficiency and effectiveness. In particular, time, boundaries, and interdependencies are the main difficulties in any supply chain. Besides, several security challenges are raised due to unintentional errors or intentional attacks. Existing technology such as RFID, with its potential to automate product authentications, makes possible to solve, or at least to reduce, most of the possible negative effects caused by the mismanagement of the supply chain process. In this line, technology included in the Internet of Things (IoT) can be used to enhance several aspects of the supply chain management, helping to improve demand management, customization, and automatic replenishment of out-of-stock goods while reducing inventory and distribution costs, as well as counterfeit versions of name-brand items. It also allows creating new safe and efficient schemes that help enterprises and organizations to improve quality of service and traceability to the management of transported goods. This paper proposes the IoT integration in the transport of merchandise, allowing its follow-up from the cloud. Preliminary research results indicate that the combination of ubiquitous technologies provides a more complete and efficient service.**

***Keywords*-Ubiquitous systems; Internet of Things; wireless technologies; transportation and logistics services.**

I. INTRODUCTION

Robust and real-time information is essential for the operation of any organization dedicated to the transportation and logistics sector. In particular, tracking and tracing goods is a process that can cover the determination of the current and past locations of items, report of the arrival or departure of objects and record of the identification of objects, and the location, time, and status where they were observed. Such pieces of information can be very helpful both internally and for customers. On the one hand, it can help to design and manage the Supply Chain (SC), adding value to the products, and establishing an additional customer service. On the other hand, internally, it allows examining how customers can get benefit by improving the use of resources in order to reduce storage costs, risk of loss or theft, etc.

Changes in customers' likes have increased the attention on the performance, design, and analysis of the SC in order to improve its efficiency and effectiveness, and to launch new products faster at lower costs. The managers of enterprises know that competitiveness is not only achieved by optimizing the manufacturing lines, but it is also important to improve the SC, enhancing the productivity growth.

According to the RAPEX report [1], the traceability of consumer products would improve Europe's ability to fight fraud and take action against unsafe products. This would be possible through a comprehensive control of the goods that reaches countries borders, including details such as date and place of entry as well as the origin and destination of the imports. It also stresses the importance of monitoring and control of goods at any time and place, since this would decrease the effects of dangerous goods that could enter the borders or thefts that may arise.

A study from 2004 [2] estimates that in the U.S. there were excess inventories of more than $117 billion and many enterprises lost $83 billion due to problems of coordination between different elements of the chain. In order to have an efficient SC, it is necessary to provide fast supply, be responsive to customer demand shifts, and alert about supply disruption.

In the transportation and logistics industry, automation in product monitoring and control, inventory, customer relationship management, fleet tracking, etc., is a typical issue dealt by the enterprises that offer solutions for the individual problems. The main goal of this work is to improve such solutions by making use of the IoT, through managing ubiquitous information about the transported goods with different types of communications and devices [3]. This work describes an innovative solution for the management of the complete SC process, which makes use of many different IoT technologies such as RFID, EPC, Wi-Fi, GPS, QR codes, etc. in a secure and efficient way. First, it provides the possibility of comparing the transported goods with the delivery note. Besides, it allows to observe, trace and check the merchandise from the source to the destination. In addition to this, the system offers an interface for fast checking of merchandise for authorities. Such information will benefit not only the authorities but also the exporters and importers, who can control their merchandise, ensure its reliability, optimize its transportation through adaptive travel route assignment, and provide added value to customers.

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This paper is organized as follows. A brief survey of related work is given in Section II. Some preliminaries about security aspects and risk factors in the SC are included in Section III. Section IV presents the new ubiquitous solution. Finally, Section V gives conclusions and future works.

II. Related Work

The application of IoT in the transportation and logistics sector and the SC management [4] [5], requires dealing with many different problems related to reliability and security. In [6] the author classifies several existing models to improve the SC and describes different approaches for every model.

On the other hand, it is known that most security problems in the SC [7] are related to physical issues happening along the route, such as breaks in fencing, long stops at night, stops near residential areas, regular scheduled stops, unlocked containers and unmanned trains.

The main goal of this work is to improve the productiveness and security of the SC by using today's technologies. In this regard, [8] performs an analysis of the efficiency and effectiveness after applying different strategies to improve the SC, and [9] includes a complete review of more than two hundred papers about green SC management.

In this paper we also analyse an inherent problem of the used technology, which is the cloning problem [10], consisting in tampering goods. In order to prevent it, we propose the use of an authentication P2P solution based on Zero-Knowledge-Proofs, similar to the one presented in [11].

Solutions sharing specific characteristics with the proposed app can be found in the Google Play Store, which facilitate the tracking in the SC [12] [13]. However, the app proposed in this paper allows tracking packages from many carriers with a phone or tablet, starting form the delivery note, and tracing it in a secure way till the destination, combining different technologies.

III. Preliminaries

Using a combination of international security standards, industry best practice, regional legislative documentation and experience, solutions could be provided that would enhance security in the SC, as well as provide increased visibility and efficiency, by preventing and limiting the amount of cargo theft. Other recommendations to secure SC systems are to provide all logistics partners with a set of minimal security requirements, seal containers with highly secure locks, wrap all products with non-descriptive plastic in order to confuse potential criminals, and implement information security system to ensure that product information and transportation routes are not accessible to unauthorized personnel.

All the aforementioned recommendations may be seen as theoretical because they have sense only if they are applied in practice. Thus, this paper proposes a practical system using existing technologies, which allows enterprises, customers and organizations to have more robust information of the SC in real time, and to set up alarms in case of changes in goods containers in order to reduce risk in the SC.

Measurement is the first step that allows facing to the control and improvement of the SC. It is known that improvements in quality lead to lower costs and higher productivity because they result in less rework, fewer mistakes, fewer delays, and better use of time and materials. Therefore, measuring the performance allows to set goals and evaluate progress, by identifying key aspects to refine, analyzing the results of the refinements, and solving possible problems. In particular, in the SC, to develop an improvement of any area, it is important to know the starting situation, define a realistic goal, determine how to measure the progress in the system and develop an action plan. This has been the procedure followed when designing the proposal here presented.

The Japanese philosophy known as Just In Time (JIT) is a production strategy that strives to improve a business return on investment by reducing in-process inventory and associated carrying costs. To meet JIT objectives, the process has to rely on signals between different points in the process, which tell production when to make the next part. Implemented correctly, JIT focuses on continuous improvement, so our proposal can be a useful tool to reach that goal.

Enterprises without centralized SC governance can negatively impact procurement, manufacturing and time to market processes in SC, which can impact company's financial strategy. Security risk management is an essential part of the SC governance system to ensure that risks are identified in the entire value chain and mitigated to deliver financial goals. In particular, the stages of the SC that must be covered by the system are manufacturing and distribution, suppliers, transportation, retailers, central warehouse, docks, cranes, boats and wholesale and retail distribution center.

Different goals can be defined to improve the SC logistics. Some of them are to reduce costs and maximize profits, improve reliability, minimize inventory, reduce delivery time, maximize equipment utilization, increase flexibility, improving simulation, reduce work in process, and reuse. Practical tools to process the building of a dynamic SC model allow to have valuable insights and analyse the behaviour and characteristics of a SC. Most existing models and tools have been developed to address particular issues that can be classified into the following five categories:

- Optimization: Finding the optimal operational guidelines that maximize or minimize a factor, such as minimizing costs and/or risks and maximizing profits.
- Decision Analysis: Typically involves the quantitative evaluation and comparison of two or more alternatives.
- Diagnostic Evaluation: It is usually conducted when the cause of a particular problem is unknown.
- Risk Management: SC dynamics can be severely impacted by unanticipated disruptive events.
- Project Planning: Changes in SC parts can produce disruptions, and short-term/long-term inefficiencies.

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IV. Proposed Ubiquitous System

This paper presents a secure and ubiquitous system to control the goods from their manufacture until their delivery to the end customer, which makes the work easier for custom authorities and all people responsible for goods in transit.

In particular, the new system allows checking whether the collected goods are correct by detecting any error in the delivery process, provides on-line checking mechanisms and keeps a full history of the goods transportation. All this is done taking into account the security needs required during the SC process because cryptographic algorithms are used to detect counterfeit information and to avoid unauthorized reading, writing or modification of labelling goods.

The proposal implies a minimum cost as it is based on affordable and usual devices such as RFID and smartphones, so not only minimizes economic costs by using cheap passive tags, but also reduces the effort to learn to use new technology because people are familiar with smartphones.

RFID technology is extended in enterprises related to SC and it allows us validate products easily and locate them [14] [15] fastly inside the container.

A typical SC consists of five actors: supplier, manufacturer, distributor, retailer, and customer. The proposed system has different parts according to the five steps in the SC where the goods may be: generation and extraction of QR data of container goods, RFID validation of goods, web service for fleet tracking and traceability, and Wi-Fi P2P request for customs check.

There are different kind of relationships in the SC and each one has different characteristics that must be resolved in a different way. Fig. 1 shows different technologies we proposed in order to have the best solutions for these relationships.

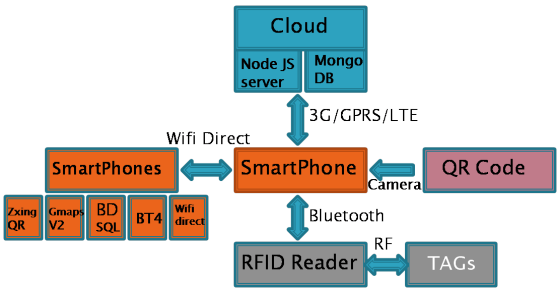

Figure 1. Related IoT technologies for the SC system

A. QR Container Receipt

The first step in the operation of the system is the generation of the container receipt describing relevant information about the products available in the container. The specific format of such a receipt consists of: receipt ID, 13-character codes identifying the products and number of each product, origin and destination places and corresponding dates, and other important data such as related enterprises and carriers.

The system generates a QR code containing all the information of the container receipt, and encrypts it so that the only way to read its content is by using the shared secret key. Such a QR code is printed in the same data sheet of the container goods.

The QR code with all information is generated with an on-line service in [16], to encrypt the information, data must be ciphered before generate the QR code.

B. QR Data Extraction

The driver who transports the goods executes the second step of the process. He/she has to use his/her smartphone to read the QR code with the app (see Step 1 in Fig. 2), and the content is decrypted with the shared key. After reading the code, the driver gets all the information of the QR container receipt.

The implementation in the Android platform for reading QR code is by using a library called Zxing, after this, data are saved in local device in a sql database. Information about origin and destinations are also shown in the device interface by using Google Maps Android API v2.

C. RFID Validation

With the list of transported products in the smartphone, the device may be used to read the RFID tags in the container through an RFID reader and a Wi-Fi interface to communicate with it. After this reading, the smartphone checks if every product in the list is in the container, (see Step 2 in Fig. 2). This is especially interesting not only in the loading of the goods in the container, but also in every delivery of goods in order to avoid possible errors. RFID technology is also useful to know the position where a product is inside the containter.

D. Web Service for Fleet Tracking and Traceability

On the one hand, fleet tracking allows checking if the goods are in the place they have to be at every moment. (see Step 3 in Fig. 2). On the other hand, traceability allows knowing specific details about the path of the goods, detecting possible bottlenecks in order to improve next parts of the route. The on demand request options enable asking the driver's device, which asks to the RFID reader of the container in order to know if everything is fine at that moment. The driver's smartphone returns the answer that can be either OK or Error, and in this case some details about the problem are attached. It is remarkable that only users who are authenticated in the system and with the corresponding permission can ask to the driver's smartphone.

This system also allows to configure goods reception and when the container is next to the reception place, the driver's smartphone will send automatically a message to the responsible of reception. To ensure the privacy and security of data, the server in the cloud is secured. For the implementation of the Web Platform we are using a Node

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JS server with Mongo DB for data and express, framework to create the webservices for Node JS. For the front-end we are use Bootstrap framework and GMaps Api.

E. Wi-Fi P2P Request

In order to facilitate authorities work and merchandise management, the app includes an authority interface that agents can use to examine the content of every container without looking inside. (see Step 4 in Fig. 2). In this way, they can check easily if all the information about goods, enterprises and carriers are correct. Otherwise, they do a physical control so that they can check the content and see if it corresponds to the information the system provides. This interface is secured as only authorized people can access to the information through it. In particular, a lightweight P2P authentication method similar to the one presented in [17] is used. This interface will be implemented by using the Wi-Fi Direct APIs for Android.

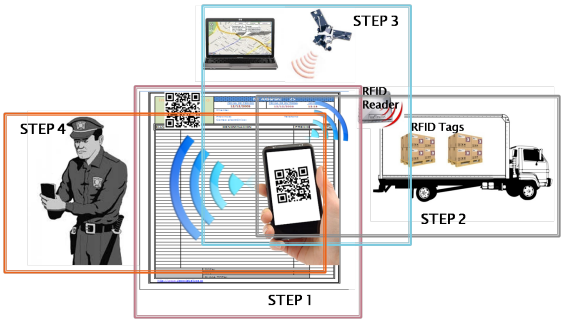

Figure 2. Complete System for Ubiquitous SC.

V. Conclusion and Future Research

In this work, a new logistics system combining different technologies to improve the efficiency and security of the SC is presented. In particular, it allows checking the merchandize not only in the loading and delivery moments, where most problems usually happen, but also at any time, as it offers tracking and tracing of goods. Furthermore, the system's interface to control the merchandise facilitates the authorities' work to perform the merchandise management in custom areas. This tool is its Beta version for the Android platform and will be soon available in the Google play store. Since this is a work in progress, there are many open questions such as the analysis of which are the most appropriate encryption mechanisms for the different communications. The analysis of the time and risks in the proposed SC tool, as well as a comparison between the improvement degree of our proposal and other systems are also future works.

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