REAL-TIME TRACKING AND INCIDENCES MANAGEMENT
Improving the Transportation of Industrial Equipment through an ICT Solution

Keywords: goods traceability, transportation of industrial equipment, fleet management, incidence recovery.

Abstract: This paper describes an ICT solution for real-time tracking and fleet management which can be applied in distribution of industrial equipments, in order to improve the traceability of such goods. The solution includes a support sys-tem for the driver that is capable of reporting the route that has to be followed and notifying incidences that occur during the trip, resolving them as soon as possible. A first prototype has been developed and its functionality validated through a simple test case. In addition, future actions to improve the system are shown.

1 INTRODUCTION

In just a few years, logistics processes in distribution of goods have improved substantially, resulting in an increase of the productivity and quality of services. To achieve these improvements, new technologies have played an important role in some areas such as goods traceability (Cleland-Huang, Settimi, Romanova, Berenbach and Clark, 2007). Moreover, traceability is a key factor in the distribution of goods because it can improve the competitiveness of a company.

In fact there are some industries in which the traceability is a very critical requirement. For example, concerning to agricultural industry, Regulation 178/2002 requires the traceability of foods in the European Union in order to know the source of each food and the route followed to reach its destination (Schwägele, 2005). Other critical industry is the pharmaceutical one, where lately a lot of trends are arising. In this industry, solutions for medicines tracking have to be deployed as far as possible in order to prevent counterfeit of drugs, assure their source, so as to guarantee that they arrive where they are expected to.

An unexplored sector is the manufacturing one. Specifically, the distribution and transportation of equipments, where the main goal is that all components of an equipment arrive together to their destination as soon as possible, in order to assemble the equipment and begin to produce manufactured goods. The traceability of this kind of components, as well as the capacity to get an efficient fleet management, route planning and incidences recovery, will increase the productivity of the manufacture companies. It is a consequence of the improvement of the way in which the distribution of the components that compound each equipment is done and the reduction of the time needed to resolve problems during their distribution.

Information and Communications Technologies (ICT), due to the latest advances in positioning, wireless communications and radio frequency systems, have become the new hope for improving such activities. In fact, the result of the work described in this paper is an ICT solution for real-time tracking and fleet management which can be applied in the transportation and distribution of manufacture equipment. Further-more, this innovative solution is able to manage routes and operations, as well as onboard support to the carriers, enabling an agile response to incidences happened during transport. In the second section of this paper, the related work is analyzed. In the third section the context of our work is presented, as well as its functional requirements, technical description, challenges and innovative contributions. In the fourth section a first prototype is presented and some results obtained in a test scenario. Finally, the future work and conclusions are presented.

2 RELATED WORK

It is a common requirement in different kind of industries to track the route of each product being shipped from supplier to customer. The importance of tracking goods has reached such a point that is being regulated by law in some countries. For example in Europe, Regulation 178/2002 requires the traceability of all food from farms to the end of the supply chain. This is one of the reasons because most of the projects about tracking are focused on the food industry, as for example the Trace FP6 project (http://www.trace.eu.org) or those ones based on RFID technology and described (Abad, 2009); (Kelepouris, Pramatari and Doukidis, 2007); (Manikas and Manos, 2009). There are other critical sectors as the pharmaceutical one. Thus, the PharmaX initiative is proposed to shed light on the pharmaceutical traceability and overall-process regulation. This system ensures that all pharmaceutical supply chain participants can integrate with each other, resulting in information sharing, consistency checking and anti-counterfeit (Huang, Zhifeng Qin and Ting Qu, Qingyun Dai, 2010). Other related challenge is the use of ICT to improve logistic processes in intermodal transportation, as is being done in TIMI project (www.proyecto-timi.es).

When performing the above projects and other similar ones, actually they are seeking the following benefits: processes automation, turnover increase, and stock management improvement (Bertolini, Bottani, Rizzi and Volpi, 2010). In fact, there are many other sectors where new technologies are applied to improve goods tracking and achieve these goals. For example, Galeria Kaufhod in retail clothing market is using RFID to automate logistics processes of the store. Thus, it is possible to improve the inventory or count the entry of goods, among other benefits (Al-Kassab, Blome, Wolfram, Thiesse and Fleisch, 2010). Other example is found in Dell Company. Changing from barcodes to RFID they have reached a big improvement in their logistic: read-accuracy improved from 95.8% to 99.8% and Mean-Time-To-Repair was reduced by 38%; the Return-on-Investment was 122% (Crowl, Mares and Moore, 2006).

The use of this kind of ICT tracking solutions in manufacturing industry is a great innovation because there are not a lot of previous references in this sector. Further-more, the transportation of industrial equipment has some additional technological challenges to be faced, such as interoperability with manufacturing information systems, real-time fleet and goods traceability, management and monitoring of the route and job actions, providing of onboard information to carriers, and real-time incidence management and recovery. The result of our work is an ICT solution with real-time tracking capacities for improving the incidence recovery timing in the transportation of industrial equipments. That is, an innovative characteristic is that it provides an ICT-based support for all the above processes.

3 FUNCTIONALITY AND TECHNICAL FEATURES

The scope of the project covers all the stages included in the distribution process of industrial equipment. Functionalities are described below (Figure 1), which have been developed thanks to the use of different technologies. At this point, we are going to describe each function of the system and its technical implementation.

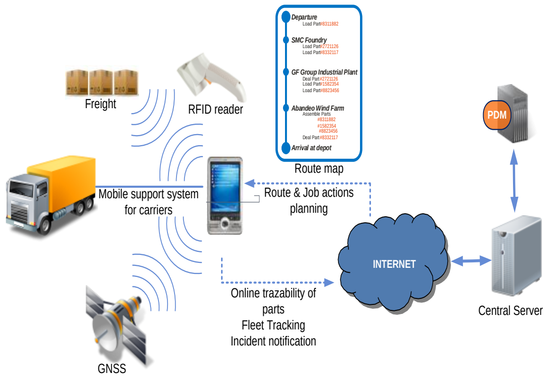

Figure 1: Architecture of the proposed solution

3.1 Planning, Route Monitoring and Job Actions Management

First of all, it is necessary to mention the overall system behavior concerning to the routes planning activity. The planning server receives information about the pieces that will be needed to transport. This is done by integrating our server with the Product Data Management (PDM) system included in the business software suite installed in the plants of the company. The aim is to have access to certain tables managed by this system and be able to read tasks list and manage status assigned to each task in terms of demanded, under development and performed. The integration is done using SOAP messages to a web service developed for the PDM system, As result of integrating with this service, the planning server can get information about the materials needed for each task, their physical characteristics (size, weight, material, etc.), the place of collection and delivery, and all actions needed for final assembly of parts. This information is used to generate truck routes for every transport service. These routes determine actions to be performed by the staff of the company indicating the stops for each vehicle, the order they must be carried out and detailed list of every job action to be executed at each point along the route. The most common actions included are the collection or loading of materials, unloading and subsequent assembly and installation of different components that make up each end equipment, so as maintenance activities required by them. It uses a simple algorithm that divides the action between the vehicles of the company taking into account their physical capacity up and its geographical location, setting the route for each vehicle. Once established, the routes are sent to the staff by the “carriers supporting device” (whose function is detailed below) to be executed in the shortest possible time. This route is stored in what has been called a route document, which is an XML formatted document that includes hierarchically the stops on the route, the actions to be carried out at each stop and parts involved in every action. For each piece, in addition to its relevant data such as the name of the piece, description, etc. a unique identifier is stored coincident with the ID code stored in the RFID tag assigned. Both route points as actions are displayed in the order they should be performed. It should be mentioned that after delivering it to each vehicle it can be dynamically altered during the course if it is necessary. The following diagram shows the general structure of the document.

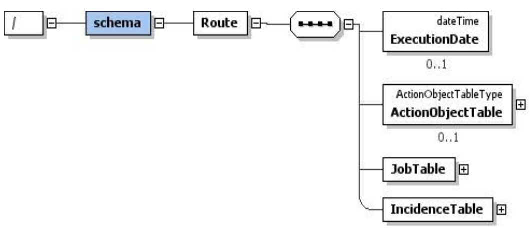

Figure 2: Document route XML Schema

Any transfer of information between planning server and each onboard mobile de-vice on vehicle (using wireless technologies such as GPRS or HSPA) will be carried out by sharing this document. Moreover, all advances in the development of the activity planned for each route (identification of the materials involved at each stop, detection of incidences, etc.) are recorded in this document by the onboard mobile device. Thus, the importance of the document is as relevant that it allows comparing the planned and real times in the implementation of the tasks and carrying out the traceability of shipped parts. When a vehicle suffers an emergency incidence or if the deviation between the scheduled time and the execution is critical, the route of one or more vehicles can be replanned by simply updating XML file for each mobile device.

3.2 Fleet Online Tracking and Traceability of Parts

As we have mentioned, each vehicle has a specific route that gives the list of actions to carry out. More specifically, the document with the route and list of actions is stored in an onboard mobile device, implemented on a smart phone with HSPA and GPRS connectivity and built-in GPS receiver. This device is responsible for periodically sending the position of each vehicle, so all vehicles can be monitored through a basic real-time fleet tracking system as well as storing routes performed by each vehicle for further analysis. Moreover, all the parts handled by the system are labeled with an RFID tag that allows tracking and ensures the proper selection of the different parts involved in each job action. Traceability of the parts is performed by the carrier with the help of a portable RFID reader that connects mobile device through Bluetooth connection, allowing validate all parts involved in each action and notify immediately every error in parts selection to the planning server. In that way the impact of the incidence can be reduced. Subsequently, the information stored by the tracking system can locate the source of each piece installed in an equipment and the current location of each piece supplied.

3.3 Carriers Supporting Device

Each employee responsible for a vehicle has a mobile device that will guide the development of assigned tasks. This mobile device hosts a resident application, which using a user friendly graphic interface, includes driving support to reach each stop on the route established, shows the list of job actions to be carried out at each point of the route, the parts or materials involved in a particular action, and allows validating the implementation of these actions through the traceability system. In addition, internally the device is equipped with a GPS receiver and is permanently connected to the server to reveal the positioning of the vehicle and the moments in which takes place every planned action. It means that, through GPS, system notices the driver when is arriving to a point of the route, helping him find the place. Finally the user can notify all relevant incidences that have happened

Figure 3: Initial planned route and tracking of the truck position

such as an accident or breakdown, filling out a simple form that is immediately sent to the server.

3.4 Incidences Management

Information sent by the previously described device allows detecting significant deviations from the planned time and rescheduling the routes and job actions assignments to different involved vehicles in order to minimize the time needed to resolve the problem. The system distinguishes between manual incidence (required by a worker) and automatic (directly sent by the mobile device); and from emergency incidence, which must be notified immediately to the planning server, or informative because it does not significantly affect how the transport service is done. When materials are being recorded by RFID and a product that should not be read is registered (part is not included in the route document) or when concluding an activity without validating document specifications, an automatic incidence is generated and written in the XML file, indicating the details and where it has occurred. Apart from this, the application allows writing an incidence manually by the driver himself filling out a simple form. If in this form the incidence is marked as urgent, it is sent to the scheduler at the time. In these cases the scheduler can replan the route of one or more trucks, shorten the route of the truck concerned or just do nothing.

4 TESTING AND EVALUATION

In order to validate the system developed at this moment, a test route has been created for a truck with 3 stops: Gamesa, Acciona WindPower and WindFarm "La Muela", which must initially be accessed sequentially. At each stop, a number of

Table 1:Places of the initial route planned by the server for one truck, its location coordinates and the job actions which have to be carried out in each stop. Numbers in brackets represent the units affected.

Place	Longitude	Latitude	Actions	Parts
Gamesa	-2.858767	43.285564	Charge Charge	Turbine A (3) Blade A (1)
Acciona WindPower	-1.639194	42.611917	Discharge Charge Charge	Blade A (1) Turbine B (1) Blade B (2)
WindFarm "La Muela"	-1.157598	41.593044	Discharge Dischage Discharge	Turbine A (3) Turbine B (1) Blade B (2)

actions must be made: in Gamesa, to charge 3 turbines of type A and a propeller blade of type A; in Acciona WindPower, to discharge the propeller blade of type A and to charge two propeller blades of type B and one turbine of type B; finally, in WindFarm “La Muela”, to discharge 3 turbines of type A, one turbine of type B and two propeller blades of type B. See the route details in Table 1.

This route will test the basic functionality of the current system: communication platform, fleet and goods tracking, on board support information, and incidence detection. Other capacities, such as intelligent planning of routes and job actions, will be developed and tested in the future.

Once the carrier is authenticated by the mobile solution, the route of Table 1 is downloaded from the Planning Server. Once route is shown by the mobile application, transport service starts driving to the first destination. Fig. 3 shows how the Planning Server is receiving positioning from each vehicle.

When vehicle approaches the desired place (Gamesa), the location icon in the mo-bile application changes of color and warns us. Once in destination, the driver chooses the option “Actions TODO” in the application menu. After choosing the action “Charge”, mobile device establishes Bluetooth connection with the RFID reader and records appropriate part IDs (turbines of type A and propeller blade of type A) to complete the action. Figure 4 shows the user interface of the mobile application which enables to perform the functionalities described above.

Figure 4: Carrier support mobile application

Once all actions assigned in the first stop are correctly performed, carrier drives to the second one, Acciona WindPower, where two actions are planned. The first one, which is discharge a propeller blade of type A, is performed validating the RFID code. And in the second action, which should be charging one turbine of type B and two propeller blades of type B, RFID reader only registers two propeller blades, so when employee ends this action, the application will alert him indicating that some materials are missing. Accepting this issue, an automatic incidence is automatically sent to the Planning Server. The route will be changed by adding an additional stop where retrieve lost (see Figure 5).

This route is sent to our mobile device and with the updated route we can continue the job. Now we

Figure 5: Route changed: an additional stop has been included

have a new stop (Eólicas Riojanas, S.L.) where we have to collect the material we needed (one turbine of type B). Thus, arriving at WindFarm “La Muela”, we can discharge all the components we have.

After finishing the test we can conclude that we obtain the expected results, detecting incidences in real time and minimizing the time needed to manage them.

5 CONCLUSION

The result of our current work is an ICT solution with real-time tracking capacities for improving the incidence recovery timing in the transportation of industrial equipments. It is considered an innovative solution because it faces technological challenges concerning to this transport, such as interoperability with manufacturing information systems, real-time fleet and goods traceability, management of the route and job operations, onboard information to carriers, and real-time incidence management and recovery. Now, a first prototype has been successfully validated.

The current implementation of the system uses passive RFID tags that should be verified by a portable HF RFID reader which connects to the mobile device by simply sending ID codes of the RFID tags. These passive tags can be replaced by active ones which can store more information and improve the reach of the reader. In that way, the employee does not have to validate each individual piece with the portable RFID reader, but can perform the tasks of loading and unloading of materials being automatically validated. Consequently the traceability of goods can be carried out in a non-intrusive way (without modifying the behavior of transport staff). This will made the system portable to other areas such as rail or pharmaceutical. Other important aspect of future work must be to improve the way in which the planning of the routes and job actions is done, because a non-automatic process is used in this moment. A higher level of automation in the task of rescheduling, based-on the use of Artificial Intelligence techniques, is a desirable issue.

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