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Original

Logistics in a Connected World: Industry 4.0 and Open Source Technologies / Alessandro, Delfino; Lorenzo, Damiani; Roberto, Revetria; Schenone, Maurizio. - STAMPA. - II(2017), pp. 946-951. ((Intervento presentato al convegno The World Congress on Engineering and Computer Science 2017 tenutosi a San Francisco, USA nel October 25-27, 2017.

Availability:

This version is available at: 11583/2693192 since: 2017-11-22T11:42:24Z

Publisher:

S. I. Ao and Craig Douglas and W. S. Grundfest / Newswood Limited

Published

DOI:

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Logistics in a Connected World: Industry 4.0 and Open Source Technologies

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Abstract— Nowadays the price of electricity depends on many factors; the introduction of renewable energy sources has changed the basics of electricity production and the determination of energy price. Iron and steel industries have the necessity to forecast the power amount they are going to spend: today production planning is performed without taking into account that the difference in electricity price between night and day can overcome 500%. The aim of this work is to create a model able to estimate energy requirements for iron and steel industry; the model correctness is assessed, for both energy and power analysis, by comparison with real data. The provisional planning tool is employed to provide data to a computer platform able to assess, on the basis of required energy, the best market on which power can be purchased in view of a money saving for the Company.

Index Terms— Open source technologies; Logistics; Management Software.

I. INTRODUCTION

A logistics company has to chase many objectives to obtain exposure into the market and to be as competitive as possible in the relevant sector.

One of these targets is to achieve integration among his many departments; it becomes necessary for a lot of reasons, for example the consequences of a choice made in a department that impact on all the others sectors of logistics.

In this way the idea of the Supply Chain Management was born.

This term explains the management of the flow of goods and services, involves the movement and storage of raw materials, of work-in-process inventory, and of finished goods from the point of origin to the point of consumption.

Therefore, while the traditional management of logistics deal mainly with the optimization of the flow inside the company, the Supply Chain Management recognizes that this internal integration isn't in itself enough, and so aspire to create and to optimize [1-3] the bonds and the coordination between the procedures of the other companies, suppliers and customers [9].

According to this, it is clear that, for a logistical company dealing with transportation, it results essential to be

equipped of systems and software for the management of the vehicle fleet and for the optimization of his processes.

This concept aims to improve the transports' efficiency and to decrease wastes of time.

For this purpose it can be useful to show the working principles of a Fleet Management System and the advantages which his application could involve.

II. FLEET MANAGEMENT SYSTEMS

For a logistical company dealing especially with road transport, the vehicle fleet is the main resource and without it transport services couldn't be distributed.

So the management of the vehicle fleet gets a position of fundamental relevance for the improvement of the business efficiency.

Initially the activities of fleet management were made manually with sheet of trip and drivers' report, which only later were inserted in a specific database.

In the last years, with the development of computer technologies and telecommunications, it is possible to monitor and to plan the transport thanks to the diffusion of devices as mobile telephony, satellite navigation systems and software.

The implementation of these technologies in the field of fleet management led to the creation of telecommunication systems known as Fleet Management Systems.

These systems offer features like the tracking and the monitoring in real time of the vehicles' position and of the driving time, the remote survey of information about the vehicles' operation, and the planning of all the vehicles' activities, from the transport's performance to the maintenance service.

The reasons why the transport companies are convincing themselves to heavily employ the Fleet Management Systems, are mostly of competitive nature: fiscal pressure, increasing requests of customers and strict laws about driving and resting time.

The application of these systems presents many advantages, for example: decreasing costs, improvement of management of every vehicle by avoiding useless trips and reduction of fuel consumed and maintenance cost.

The Fleet Management Systems are an excellent example of Industry 4.0, term which indicates the Fourth Industrial Revolution which is taking place in the last years.

Industry 4.0 describes a new trend of industrial automation which makes use of innovative manufacturing technologies for the purpose of improving the working conditions and increasing the productivity and the

Manuscript received August 10, 2017; revised August 22, 2017.

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productive quality of the machineries [8].

Industry 4.0 is based on the concept of Smart Factory and on some new technologies; one of these is known as Internet of Things.

Internet of Things (or simply IoT) is a neologism which indicates the inter-networking of physical devices, vehicles, buildings and other items embedded with electronics, software, sensors, actuators and network connectivity which enable these objects to collect and exchange data [9].

The idea on which Internet of Things is based, is the expansion of Internet to the world of the real objects and places; this is the same idea on which the Fleet Management Systems are based, which have the fundamental purpose of connecting the vehicles to the Internet, in order to they can communicate their position and other information to the operations center.

For this purpose, the Fleet Management Systems use some technologies, some necessary and some not auxiliary.

The most important technology in support of a Fleet Management System is the GPS (Global Positioning System).

This is a system to determine a vehicle's position, based on accurately measuring the distance to four or more satellites.

The satellites transmit precisely synchronized signals based on a very accurate clock contained in each satellite.

The receiver estimates distance from each satellite and determines its location by observing the phase differences of the signals from the satellites.

Taking advantage of a GPS, the Fleet Management System is able to know the real time position of all the vehicles belonging to the fleet.

To track a vehicle by a GPS, it must be equipped with a specific device provided with this technology.

There are many devices available into the market which can conduct this assignment, from the basic one which can only track the vehicle's position, to the most advanced one which can be able to send signals and messages of various kinds.

An example of these devices, easy to obtain and to set up, is the modern mobile telephone: the smartphone.

By now there are many models of smartphone, a lot of these with an accessible price, and all of these equipped with a GPS.

It will be sufficient to download a specific app and to set up it on the smartphone to connect it to the server of the system; in this way the smartphone will be able to exchange data and information about the vehicle with the operative center.

Another fundamental technology for a good Fleet Management System is the GIS (Geographical Information System).

This system is based on an accurate and detailed database of all streets, highways, addresses and other physical features in a region, usually complemented with a graphical display capability.

It is necessary to implement the software with this particular technology in order to see the vehicles' position on a map; the result is an easier identification and management of the fleet.

In addition to these necessary technologies, there are

other auxiliary tools which can be used for the correct operation of the system.

Most of these are particular sensors, each one with a specific aim, for example: a sensor for the survey of the fuel consumption; a sensor for the measuring of the refrigerating room's temperature, in the case of a transport at monitored temperature; a scale for the measuring of the weight in the room assigned to the transport.

In this study, it was contemplated the possibility of making use of an open source technology as a Fleet Management System.

In the following pages the possible advantages and benefits of this choice will be analyzed.

III. OPEN SOURCE TECHNOLOGY

A logistical company, which wants to use a Fleet Management System to optimize his transports' efficiency, can choose between two possible alternatives.

It can invest substantial amounts of money, either buying a complete system ready to use or paying many programmers to realize the entire software starting from scratch.

Otherwise it can choose a cheap way, making use of an open source technology.

This kind of technology specify a software with its source code made available with a license in which the copyright holder provides the rights to study, change, and distribute the software to anyone and for any purpose [9].

In other words, an open source technology is a computer software which can be downloaded for free and edited with improvements and extensions in order to personalize it on own needs.

Implementing this kind of solution can lead to many advantages.

First of all it requires low initial investments, and this involves to take less risks for the project.

Secondly it's a software quick to install and to set up, and it is usually easy to use; so it is a solution which requires less time than other possible applications, but it allows to have many benefits in a short time.

Therefore, the set of low investments, quick times and achievement of fundamental objectives, lead to have a good quality for the project and at the same time for the customer service.

From these observations it is evident that the implementation of an open source technology is a good solution, especially in the short term, because it is endowed with the essential features required from the user and it allows the company to quickly realize a reliable product with an innovative purpose and with a limited investment.

Inasmuch the aim of this study were the Fleet Management Systems, it was searched an open source technology with these characteristics.

With this in mind, it has been selected the Open GTS software.

IV. OPEN GTS

Open GTS (Open source GPS Tracking System), by GeoTelematic Solutions Inc., is the first available open source project designed specifically to provide web-based GPS tracking services for a "fleet" of vehicles [8].

It is designed to work independently with any type of device equipped with a GPS tracking, both with smartphone and with more technologically advanced instrument.

In order to enjoy the use of Open GTS, after obtaining a specific license, it is necessary to download the software and to install it on a high performance server.

Once completed this stage, it will be possible to connect remotely to the system through the internet, taking advantage of the server URL and of own credentials; in this way it will be possible to examine and to monitor own vehicle fleet at anytime and anywhere, without necessarily being at the operations center, but only using a laptop or a smartphone connected to the internet.

Among the various services offered by Open GTS, as well as being able to see in real time the positions and the movements of all the vehicles on the map, there are also many report tables which make available, in a quick and easy way, data related to own fleet, with the ability to focus on the area of greatest personal interest.

Some of the features and tables available on Open GTS are [9]:

- Tracking Vehicle Location: it is the main function, which allows to map the position of all vehicles belonging to the fleet. In this section it is possible to choose the date range in which you want to trace the vehicle's movements; so you can see both the real time position of the vehicle and his movements in a past day. The vehicle's movements will be shown on the map with a series of points, each at a place where the device sent a signal to the server. There will be green, yellow and red points, depending on the vehicle's speed. There are different kinds of signals which can be sent by the device: Resume (when the device is switched on), Start (when the vehicle starts to move), EnRoute (when the vehicle is in motion), Heading Change (which indicates a significant change of route), Stop (when the vehicle stops for more than a threshold value of minutes), Dormant (indicating that the vehicle is stationary for 30 minutes but the device is still on), Suspend (when the device is turned off). On the screen there is a link named " Show location details ", in which it is possible to obtain more information about every point on the map. There are information about device's name, status, date, time, GPS coordinates, speed, heading and address (if available). There is also the possibility to see the entire fleet or a group of vehicles at the same time on the map.
- Event Details Report: it is a table which reports all the events that the server has received from a specific device/vehicle in a selectable time frame. This table is a more detailed version of the previously quoted " Show location details ", and therefore retracts point by point all the signals which have been sent by the vehicle along its way. There are information about date, time, status, latitude, longitude, speed, altitude, odometer and address. It is possible to obtain this kind of report for all the vehicles of the fleet and about every day of work. In this section it is also possible to see the last known location of all the vehicles.
- Driving/Stopped Time Summary: it is a report designed to offer to the user a lot of information about driving time of a single vehicle. It shows how much time the vehicle has spent driving, how long the journey was between two subsequent stops and how much distance was covered between them. Additionally, the report shows the total time in which the vehicle was stationary, the number of times in which it stopped, the duration of the stops and where these occurred. In order to obtain this kind of summary, it is necessary first to choose how stops will be detected by the program. The simplest and most accessible way with any type of device attached to the vehicle is to rely on a predetermined amount of minutes the vehicle has been stationary; in this case, it is possible to choose from various options, from the most radical one which signals all instant stops, to the one which reports only stops of 30 or more minutes. If, on the other hand, the device used by the vehicle is also equipped with a ignition sensor, capable of alerting when the vehicle is on and when it is off, and not only when it is stationary, then it is possible to base the search of stops on that sensor; in this way it is possible to distinguish stops due to, for example, traffic and traffic lights, from the most important ones due to cargo loading / unloading of goods or rest of the driver. The use of this report allows the fleet manager to identify which stops last longer than necessary and which have been unnecessary. Additionally, observing the driving time elapsed and the distance covered between two known destinations, it is possible to determine whether the vehicles have been guided as efficiently as possible.
- Speeds Over Limit: it is a report which shows if, when and where a specific vehicle has exceeded a particular speed limit. Obviously, the speed limit threshold can be edited at any level considered to be relevant to the interests of the end user. In this way, it is possible to impose the speed limit in effect in a specific country and check when a vehicle has exceeded it. By providing such concrete information to check driving behavior, it is therefore possible to perform corrective actions with the driver before a road accident occurs.
- Geozones Creation: it is a particular function which allows the user to create geozones, which means areas of interest on the map, within which the devices can communicate accurate information to the server. In particular, devices will send a predefined signal to the server each time the vehicle on which they are mounted enters and exits the geozone. So it may be very useful and convenient to set up own main warehouses and logistic nodes such as Geozone in the program, in order to know in real time when a vehicle arrives in or departs from that area. The impact that this function can have from the point of view of vehicle fleet management is evident, as it allows to know the time of arrival and departure of vehicles from logistic nodes and the number of those which are present in each node and at any moment, facilitating vehicle management, greatly expediting delivery times and significantly reducing fleet management costs. A geozone can be defined around

any reference position; once its creation is completed, the vehicles' movements through it will complete the event details report with the specific description of the geozone, that means a personalized address.

- Administration: it is the section of the program where it is possible to manage it. In this section can be added or edited the users of the system, the vehicles to be tracked and the geozones. Additionally, it is possible to subdivide the entire vehicle fleet into various groups, depending on own needs.

In order to have a direct experience of how a Fleet Management System, as Open GTS, could influence the daily management of a vehicle fleet from a logistical company and improve its efficiency, during this study a practical test of the software was carried out on behalf of a local company.

The following pages will analyze the work done in this case.

V. CASE STUDY

One of the main goals of this study was to test the Open GTS software for managing the fleet of company vehicles.

So, after successfully installing the software on a University server, a test was carried out on behalf of the Consorzio Abaco.

Consorzio Abaco, based in Genoa, is a consortium which manages a group of companies that deal with various sectors, including logistics.

The test was performed collaborating with a single company of the consortium, which mainly deals with the logistics of the transports: Tiemme.

The goal of the test was to evaluate the potential benefits in managing the vehicle fleet brought by the use of the software.

The test lasted a month and has involved three vehicles of the company.

Drivers of the test vehicles have received a smartphone equipped with a GPS tracking application, and they have received instructions to turn it on at the time of departure and to turn it off at the time of arrival.

The data of the smartphones had previously been included in the software, so that it would recognize them and track them.

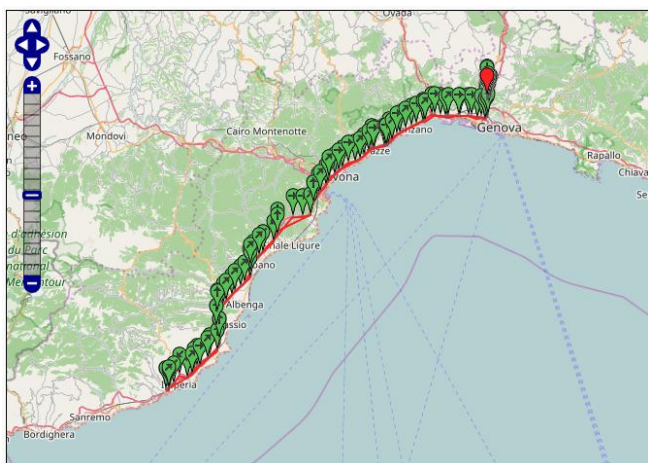


Fig. 1. Path traced on a test day.

This was the beginning of the trial period of the program; at a later time, as the system was working, it was decided to enter the first three geozones into the program, selecting them among the most important warehouse and the most frequented logistics centers by test drivers.

During the trial period, contact with Consorzio Abaco and Tiemme was constant, both to provide them with updates on the test and to decide together any modifications and improvements to be made to it.

All points marked on the map correspond to signals sent by the device; these signals are automatically collected, sorted and arranged by the program in appropriate tables, which also contain important information on the position and status of the vehicle, as well as the nature of the signal being emitted.

Fig. 2 shows, for example, a detail of a table collected on one of the test days.

#	Date	Time	Status	Lat/Lon	Speed km/h	Altitude meters	Odometer Km	Address
1	2017/03/22	06:02:24	Resume	44.46549/8.89801	12.1 S	93	1803	
2	2017/03/22	06:02:35	Start	44.46486/8.89778	34.1 SW	91	1803	
3	2017/03/22	06:03:08	Heading_Change	44.46098/8.89762	28.3 SE	90	1804	
4	2017/03/22	06:03:18	Heading_Change	44.46107/8.89832	30.2 NE	91	1804	
5	2017/03/22	06:03:34	Heading_Change	44.46159/8.89905	16.4 N	93	1804	Via Bruzzo 16, Bolzaneto
6	2017/03/22	06:04:24	Heading_Change	44.46625/8.90130	47.1 NE	93	1805	
7	2017/03/22	06:05:17	Heading_Change	44.46937/8.90707	27.4 E	100	1805	
8	2017/03/22	06:05:25	Heading_Change	44.46890/8.90707	39.0 SW	101	1805	
9	2017/03/22	06:05:41	Heading_Change	44.46932/8.90557	16.4 NW	99	1805	
10	2017/03/22	06:06:07	Heading_Change	44.46797/8.90466	31.6 SE	99	1805	Mercato Bolzaneto, Via Sardorella 10r
11	2017/03/22	06:06:51	Heading_Change	44.46544/8.90311	16.1 SE	96	1806	Mercato Bolzaneto, Via Sardorella 10r
12	2017/03/22	06:10:08	EnRoute	44.46545/8.90375	0	98	1806	Mercato Bolzaneto, Via Sardorella 10r
13	2017/03/22	06:19:03	Stop	44.46578/8.90358	0	109	1806	Mercato Bolzaneto, Via Sardorella 10r
14	2017/03/22	06:45:03	Start	44.46590/8.90422	0	72	1806	Mercato Bolzaneto, Via Sardorella 10r
15	2017/03/22	06:45:26	Heading_Change	44.46634/8.90439	0	94	1806	Mercato Bolzaneto, Via Sardorella 10r
16	2017/03/22	06:51:57	Stop	44.46659/8.90445	0	114	1806	Mercato Bolzaneto, Via Sardorella 10r
17	2017/03/22	06:53:44	Start	44.46614/8.90409	0	87	1806	Mercato Bolzaneto, Via Sardorella 10r
18	2017/03/22	06:53:46	Heading_Change	44.46580/8.90353	0	95	1806	Mercato Bolzaneto, Via Sardorella 10r
19	2017/03/22	06:57:46	Stop	44.46561/8.90380	0	67	1806	Mercato Bolzaneto, Via Sardorella 10r
20	2017/03/22	07:27:47	Dormant	44.46561/8.90380	0	103	1806	Mercato Bolzaneto, Via Sardorella 10r
21	2017/03/22	07:57:47	Dormant	44.46555/8.90384	0	65	1806	Mercato Bolzaneto, Via Sardorella 10r
22	2017/03/22	08:13:24	Start	44.46524/8.90435	11.6 E	106	1806	Mercato Bolzaneto, Via Sardorella 10r
23	2017/03/22	08:13:13	Heading_Change	44.46764/8.90594	21.0 N	88	1806	
24	2017/03/22	08:13:23	Heading_Change	44.46794/8.90527	19.7 NW	99	1806	Mercato Bolzaneto, Via Sardorella 10r
25	2017/03/22	08:20:04	Heading_Change	44.46740/8.90566	29.3 SE	91	1807	Mercato Bolzaneto, Via Sardorella 10r
26	2017/03/22	08:20:24	Heading_Change	44.46564/8.90549	19.0 SW	93	1807	Mercato Bolzaneto, Via Sardorella 10r
27	2017/03/22	08:20:54	Heading_Change	44.46517/8.90481	24.4 SE	107	1807	
28	2017/03/22	08:21:02	Heading_Change	44.46500/8.90465	24.6 E	108	1807	
29	2017/03/22	08:21:36	Heading_Change	44.46702/8.90678	29.6 N	108	1807	
30	2017/03/22	08:22:03	Heading_Change	44.46827/8.90727	29.1 SE	104	1807	
31	2017/03/22	08:22:39	Heading_Change	44.46794/8.90798	11.6 NE	103	1807	

Fig. 2. Report table of a test day.

This table gives information on date, time, status, GPS coordinates, speed, altitude, odometer and address.

The last column is closely linked to the creation of Geozones; when these are created, the program will ask the return address of the zone, which will complete the corresponding column of the table when the vehicle will pass through the Geozone.

By reading together the report tables and the mapping of the paths carried out by the vehicles, it is possible to have a complete view of the activity conducted by every single vehicle on each day of the test.

All these data, sent in real time from the device, are collected from the program in a special database, and are accessible at any time from their arrival in the software.

Therefore the program was tested and monitored this way throughout the trial period.

Subsequently, a phase of analysis and study of results began, carried out together with Consorzio Abaco and Tiemme.

The aim of this analysis was to find, on the basis of the direct experience of the test, the functionality of the program considered to be most important and relevant to the needs of the company, and to hypothesize and study the changes and enhancements that could have benefited the system to be put

into operation within the company itself.

In this way, it has been drawn up a list of the seven most important functions for the daily management of the vehicle fleet, and therefore the reasons why it will be strongly useful to the consortium and his companies to install the Open GTS software:

- **Position Control:** the main function of the program, and therefore the most obvious reason for installing it, is to know and check in real time the position of all fleet vehicles at any time. The benefits that this functionality involves in terms of day-to-day management of the vehicle fleet are numerous and of various kinds; for example, the possibility to know the current position of a given vehicle without having to communicate with the respective driver, thus avoiding time losses. The software also allows you to view the current location on the map of all vehicles belonging to the entire fleet or to a single group; this feature permit to accelerate the assignment of a task arrived only at the last moment and for which it is possible to quickly get to know and contact the vehicle in the closest vicinity.
- **Creation of Geozones:** using the software to create geozones, which correspond to the main logistical nodes exploited by the company, can involve considerable benefits to the company itself. First of all, it is possible to know precisely the time of arrival and departure of each single vehicle in all warehouses and in all the loading / unloading areas that have been mapped. Secondly, the geozones' address will appear in all the tables obtainable by the software, and this can be very useful; for example, in the driving/stopped time summary, taking advantage of geozones, it is very easy and immediate to know how many stops have been made within a logistic node known for loading / unloading operations and which have been made along the way for different reasons. Using these tools provided by the Open GTS software can thus improve both the efficiency of own transport, minimizing lost time, and managing own logistic nodes.
- **Check of Stops:** using the specific stop report tables in the software, it is possible to quickly and in real-time check that every single fleet driver has a correct use of the stops imposed by law. For example, in Italy the law provides that every driver makes a stop of 45 minutes, or one of 15 minutes plus one of 30, every 4 hours and a half driving. For this purpose, it can be used the driving/stopped time summary; also, since this table can be obtained by the software at any time and above all in real time, in case of a violation it is possible to immediately advise the driver to try to limit it. This useful feature of the program is therefore a valuable tool to help the company to avoid fines or legal problems.
- **Feedback with the Customer:** the use of all the tables and tools provided by the Open GTS software allows to always have a feedback tool with the customer regarding the arrival / departure time of a vehicle and the loading / unloading time of the goods. Combining the mapping of the route taken by the vehicle with the various report tables relating to it, this is possible also in the event that the customer's warehouse has not been mapped as geozone. In addition, all data collected on report tables are automatically saved and stored by the program in specific databases, so that they can also be consulted at a distance of weeks or months. All of this allows to always have a good support in case of disputes and disagreements with the customer due to a delay in a delivery or to a no delivery arrival, always having the opportunity to try at any time the actual activity carried out by every single vehicle.
- **Speed control:** another issue that can lead to fines and legal problems to damage the company, it is the respect for speed limits imposed by law. The Open GTS program allows to make sure that traveling vehicles are always within these limits, using the speeds over tables. These tables, which like all others can be obtained in real time, indicate the number of times the selected vehicle has exceeded a given speed value. This value can be selected from a set of values preset in the program, or can be customized according to the limits in force in a specific country by means of a system reconfiguration. The table shows date, time, position and speed reached for each exceeded set threshold value. This function is very useful to know and control the driving style of each fleet driver, so as to increase as much as possible the level of safety of the transports in order to minimize the risk of accidents.
- **Service Request:** a feature which is beneficial to both the company and the drivers, it is the possibility for them to send a timely request for assistance to the operations center, taking advantage of the specific button in the application used by the smartphones. When submitting this request, the device also sends to the system the current position of the vehicle; in this way sending any kind of help can be even quicker and more accurate. This instrument can be used by drivers whenever they need assistance, both in the event of a mechanical problem of the vehicle and in the event of a road accident. This function provides drivers with quick relief at any time and everywhere, thus improving the level of safety and quality of the company's service.
- **Consortium and his Companies:** As for future developments, the idea would be to make the Open GTS software operational for the whole consortium, extending it to all its companies. This idea fits perfectly with the structure of the program, which could easily divide the entire fleet into several groups, each of which consists of all vehicles belonging to a single company. Then it could be possible to create a central account to be entrusted to the consortium manager, and create as many users as the companies. Each user would have personal access credentials, and would have a specific level of permissions to use the program depending on his area of interest within the Consortium. The one who would have all the permissions, including the ability to create new users or delete old ones, would be the central account manager, which would then have full powers within the Open GTS program. All this, summing up, would lead to significant improvements in the management of the entire fleet of vehicles belonging to the Consortium.

VI. CONCLUSIONS

From the Open GTS software test carried out during this study and from the next stage of analysis of results, it is evident how the implementation of this software can involve many benefits for a logistical company.

Indeed, a fleet management system as Open GTS allow to constantly know the position and the movements of all the fleet's vehicles, greatly facilitating their management and reducing as much as possible waste of time; and it is obvious that time saving is a key factor for a logistical company.

The benefits consist not only of knowing the vehicles' position but also of having many more information about the state of the vehicle and the driving style of the driver; the software, through his tables and reports, provides information about speed, address, service request, driving and stopped time and more.

Therefore, for a logistical company which wants to be competitive on the market, the use of a fleet management system turns out to be essential.

Among the various systems of this type, choosing Open GTS is surely a safe and reliable choice and especially cheap.

As it is an open source technology, it requires low initial investments, it can be configured according to own needs and it can be operational in a short time, thus ensuring to take advantage of the benefits of such a system.

In conclusion, for a logistical company the use of Open GTS would improve the management of his vehicle fleet, increasing his efficiency and quality of service offered to customers, while reducing management costs and waste of time.

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