Intelligent System for Dynamic Transport Fleet Management

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Abstract

This paper introduces an Intelligent Transport System we called SigFlot, which is specially designed for fleet management, using dynamic information. Its main objective is to optimally manage the resources of a transport enterprise in order to achieve a safer and more efficient transport. The system consists of one set of modules which perform different jobs: communications (GSM/SMS), location (GPS), hiring / info through the Web, geographic information (GIS), route optimizing (Dijkstra algorithm and Taboo search). This application is fully developed in Java so it eases its portability to other platforms and OS.

1. Introduction

The growing expansion of road transport, so much of passengers and goods, which provoke daily mobility to be seriously restricted. This fact affects deeply to transport enterprises, degrading the quality of its services and increasing the costs.

However those adverse effects can be mitigated or even eliminated using Intelligent Transport Systems (ITS) [1]. These systems constitute a link between the information technologies and communications, and the vehicles and networks that transport people and goods, which make them play a very important role easing sustainable mobility of vehicles.

As a concrete application of the ITS to freight transport, Fleet Management Systems can help to reduce fuel costs, improve the accuracy of deliveries and limit the number of empty travels.

Let’s focus in this paper’s objective. A telematic control platform called SigFlot was developed. Using this platform an enterprise manager can get to know the current estate and situation of all vehicles composing the fleet, share the freights optimally and also obtain the best route to arrive its destination.

This route must be calculated taking into account not only the fixed parameters of each route, but dynamic parameters too [2]. Moreover, one of this system’s strong points is its ability to manage capacity given that not only route parameters are taken into account but also some other parameters referring freights and drivers. This way, using those new parameters, this system considers the laws referring drivers, their payment, the returning home of each driver and their individual skills.

This way of optimizing both routes and transport enterprise’s resources differ from the developed by others like GMV Sistemas, Telefónica and Fagor Electronics allowing the enterprise to earn a lot in efficiency.

2. System Description

The described system has been developed in a modular way in order to make it as flexible as it is possible so it can be adapted to the specific needs of the varied transport companies. A diagram of the system can be found in Figure 1.

The flow of information between the different system’s components is performed by using TCP/IP sockets interconnections following Client-Server architecture, so it can be ran in a single machine as a centralized independent system, or separately using different interconnected machines behaving as a distributed system.
Next, we shall describe the different modules composing the system:

2.1. Main module or Core

This system follows a centralized design at information flow level, by using this; all communications between the different modules are channelled through a central manager or core.

The main advantage of this design appears when handling the information contained in the system databases, because it is a single process the one that operates over the data in a concurrent manner, which guaranties the consistency of the data and the replica control.

2.2. Data Bases

This system uses two relational data bases in order to store all the information required for the system proper working. One stores the info concerning the enterprise resources: client’s info, vehicles, loads; services... while the other stores purely geographic information related to the populations and road network.

2.3. Operator’s Interface

This module is the tool used by the system’s operator to manage the vehicles fleet as well as the others resources of the transport enterprise.

This Interface is designed to permit browsing and editing the system’s databases in an intuitive and friendly way, as can be seen in Figure 2.

By using this graphic interface, the system’s operator can carry out a complete tracking of all transport requests done by the clients either by phone or using the Internet and can also obtain in real time the position of any of the fleet’s vehicles equipped with a location module, calculate and verify the routes that must be followed in order to reach their destination…

2.4. Web Module

This module offers a connection to the system from the Internet via Web pages. Its function is to provide the enterprise’s clients with the possibility to hire on line new transport services using an application form, and obtaining information about the state of the already contracted services. It allows tracking all in transit loads through a map generated by the system, where it is shown the vehicle’s position and the route it is following, as can be shown in Figure 3. On the other hand, users wanting to register as company’s clients dispose of an application form so their data can be added to the system’s data bases.

2.5. Communications and Location Module

Its function is to establish a communications channel between the base station and the mobile units on board the fleet vehicles [3]. This communications channel is based on GSM mobile technology and SMS messaging services.
This module implementation consists of two parts: hardware and software subsystems. The first of them is composed by a GSM mobile phone, a GPS signal receptor and a laptop computer. This equipment is named TDV Terminal or On-Board Terminal. The software subsystem is mainly composed by the communications module whose function is to encode and decode the SMS messages transmitted between the base station and the mobile units.

2.6. SMS Services Module

The function of this module is to provide messaging services to several of the system’s modules.

It allows sending SMS messages to the clients with information about variations in the service, as can be seen in Figure 4, or simply as the response to a query done by the clients themselves. It also allows the base station to receive the messages originated in the TDV or sending them a positioning request.

2.7. Geographic Information Module

This module provides the rest of the system’s modules with cartographic information as they require it [4]. It consists of two independent applications: the database editor and the map server.

The GIS editor is the tool the operator can use in order to modify the cartographic information included in the GIS database.

It has a graphic interface that can be seen in Figure 5, from that interface you can modify or delete road lengths, their type or name… or add new road lengths based on a digitalized map.

2.8. Optimizing Module

This module’s function is to improve the management of the transport enterprise’s resources by assigning loads to drivers in a way that enables the accomplishing of all needed requirements and to minimize the combined kilometres travelled by all vehicles. Furthermore it indicates the shortest route and the total route performed by each truck.

In Figure 6, it can be seen an example of the calculus of the optimal route between two cities (León and Valladolid).
The influence of these factors over the route selection can be adjusted under the objective of favouring optimizing flexibility, adapting this way to the requisites imposed by each transport enterprise.

It must be taken into account that millions of possible situations must be evaluated and afterwards some restrictions must be applied over freights, trucks and drivers; however the processing time must be short enough for the module to be useful.

This module speed will logically depend on the size of the enterprise using it and the power of the machine running the software. However we’ll simplify the problem by just taking the shortest routes between trucks and loads and forgetting about the rest of the nodes. Once the problem is simplified we’ll apply the problem’s restrictions in order to reach the optimal solution reducing execution time.

In order to perform this simplification a classical shortest path problem (SPP) [5] must be solved. In accordance with a study by Zhan and Noon [6] showing that Dijkstra algorithm in both implementations based in double and approximate cubes are the best to solve one-to-one SPP and one-to-some SPP. Taking into account our study assumptions: one-to-some problem and non-oriented graph, we decided to use double cube Dijkstra implementation [7].

Any algorithm can be used to perform optimization, from neuronal network, to genetic algorithms, etc. Even brute force can be used in order to optimize, using a deep or wide search. Although the implementation was done using genetic algorithms, at a later time a taboo search was chosen [8] because it is more adequate in order to solve this particular route optimizing problem, given the characteristics of our specific case.

One characteristic that makes taboo search stand out over other methods is its convergence rapidity when we are near the optimal solution; on the other hand, genetic algorithms only converge quickly at the beginning.

3. Conclusions

Most of our contribution to the described system in the integration of advanced telematic technologies, Geographic Information Systems, optimization methods, e-commerce services and software development. We had the intention to offer a useful tool that could contribute to a safer and more efficient transport.

Nowadays, there exists a growing interest in the development of Vehicle Fleets Management Systems given the advantages and benefits that those developments can provide, not only to transport enterprises (they can improve their efficiency when offering transport services) but to civil society as a whole (providing a substantial improvement in vial security and lesser environment impact).

The displayed system is the result of a preliminary design, a prototype designed by the Telematic Group of the University of Valladolid. This system fulfils the existing void left by other solutions in a permanently evolving market.

It is also intended the system to be in a permanent evolution through constant feedback, learning of the new needs of transport enterprises, embodying the advancements in new technologies applied to Intelligent Transport Systems.

Those advancements affect, fundamentally to the communications and location modules incorporating the latest state-of-the-art in mobile communications (GPRS/UMTS) and in location (GPS/GALILEO) through a small PDA as on-board terminal.

References


