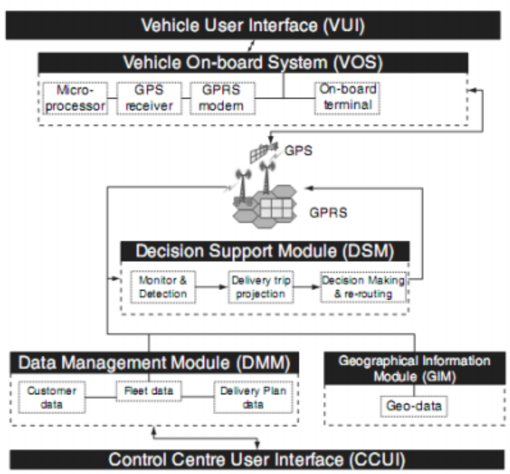
INTERNATIONAL HELLENIC UNIVERSITY
School of Economics & Business Administration
Programme: Executive MBA 2009

Advanced Technologies for Fleet Management Systems



Efstathiadis Doukas
Silkoglou Christos

Supervisor Professor:
Tarantilis Christos, Associate Professor

January 2011

Table of Contents

Executive Summary 4
Introduction 6
Chapter 1 11
1. Fleet Management System Control Centre 12
1.1: Technologies that affect data exchange and processing. 13
    1.1.1: Electronic Data Interchange (EDI). 13
    1.1.2: Push Technology. 14
    1.1.3: Floating Car Data. 14
    1.1.4: Application Service Providers. 16
    1.1.5: Remote Sensing. 17
1.2: Technologies that improve data visualization and area control. 17
    1.2.1: Geographic Information System (GIS). 18
    1.2.2: Geofencing. 19
1.3: Technologies that assist in computational methods and decision making. 21
    1.3.1: Agent-based computing. 21
    1.3.2: Front-End Intelligence. 24
Chapter 2 25
2. On-Board Technologies 26
2.1: Introduction to Vehicle On-board System (VOS) 26
2.2: Mobile Data Terminal (MDT) 26
    2.2.1: MDT description 26
    2.2.2: An example of a MDT 27
2.3: Sensors and Sensors Network 27
    2.3.1: Sensors 27
    2.3.2: Controller Area Network (CAN) 27
    2.3.3: A CAN application 28
    2.3.4: Wireless Sensor Network 28
    2.3.5: Hybrid systems 29
2.4: GPS technology on Vehicle 30
    2.4.1: GPS receiver parts and function 30
    2.4.2: Description of a GPS receiver in details 31
2.5: Radio Frequency Identification (RFID) 32
    2.5.1: Definition of Radio Frequency Identification 32
    2.5.2: Application of RFID 32

2.6: Smart mobile phones and PDAs.. 33
2.6.1: Smart mobile phone and PDA description.. 33
2.6.2: Smart phones application... 33
Chapter 3.. 34
3. Mobile and Satellite Communications Infrastructure... 35
3.1: Mobile Communications Infrastructure... 36
3.1.1: Wide Area Networks (WAN).. 36
3.1.1.1: Global System for Mobile Communications... 37
3.1.1.2: General Packet Radio Service... 38
3.1.1.3: 3G... 39
3.1.1.4: 4G... 40
3.1.2: Personal Area Networks (PAN)... 40
3.1.2.1: Bluetooth... 41
3.1.2.2: Zigbee.. 42
3.1.2.3: Radio Frequency Identification.. 43
3.2: Satellites Communication Infrastructure.. 44
3.2.1: Global Positioning System... 44
Chapter 4.. 47
4: Cybercars.. 48
4.1: Introduction to cybercars.. 48
4.2: Description of a cybercar's technology... 48
4.2.1: Main problems in cybercar technology.. 48
4.2.2: Obstacle avoidance.. 48
4.2.3: Navigation and communication... 49
4.2.4: Parallel parking.. 49
4.2.5: Platooning.. 49
4.3: Dynamic fleet management system for cybernetic transportation.......................... 50
Conclusion.. 53
References:... 55

Executive Summary

In this paper, we studied the technologies used in a dynamic fleet management system. A dynamic fleet management system is being divided into four technological fields:

- the fleet management system control centre
- the on board technologies and vehicle mobile data terminal
- the mobile and satellite communication infrastructure

The fleet management system control centre is the core of a Fleet Management System. The Fleet Management system control centre is responsible for obtaining, processing and distributing information for better use of the system, the infrastructure and the services. The control centre includes all systems and tools necessary for providing guidance to the vehicles as well as management of the fleet. Technologies included in this field are: Electronic Data Interchange, Push Technology, Floating Car Data, Application Service Providers, Remote Sensing, Geographic Information System, Geofencing, Agent-based computing, and Front-End Intelligence.

The on board technologies are the technologies used on the vehicle to acquire all the necessary data in order to have a clear view of the status of the vehicle, its freight and its position. All this information is transmitted with a selected communication system to the control centre. The on board system can also provide bi-directional communication with the driver and the router operator in the control centre in order to reschedule the vehicle’s route. Technologies included in this field are: Mobile Data Terminal, Sensors, Controller Area Network, Wireless Sensor Network, GPS receiver, Smart mobile phones and PDAs.

The mobile and satellite communication infrastructure is the technological field that is used for the communication between the on board terminal and the control centre. Technologies included in this field are: Global System for Mobile Communications, General Packet Radio Service, 3G, 4G, Bluetooth, Zigbee, Radio Frequency Identification and Global Positioning System.

Finally we have presented cybercars whose technologies are emerging, with some of them to have already been applied in industrial scale and others to be in a prototype state. Nevertheless this technology is the future of the fleet management systems. Technologies included in this field are: Obstacle avoidance, Navigation and communication, Parallel parking, and Platooning.

For every technological field that is presented, relatively papers are being demonstrated for someone to understand better the technology and its application.

Introduction

If we would like to give a definition for Fleet Management, we could say that Fleet Management is a generic term to describe the detailed management of an enterprise's vehicle fleet, using certain technologies, in order to improve operational efficiency in terms of time and cost. The vehicles could be rental cars, buses, trucks or vans, taxi cabs, ships, railway wagons, airplanes or even containers.

The management of the fleet includes a wide range of functions depending on the kind of vehicles the fleet includes, such as

- driver and speed management
- best route selection
- health and safety rules compliance
- fuel control and reduction
- vehicle financing
- vehicle maintenance
- vehicle tracking
- control of products' loading and unloading

Fleet Management is an important tool not only for the private owned companies but also for the public sector, if we accept the fact that various public organizations have to manage a fleet of vehicles in order to serve the community. For example, a municipality has its own fleet of ambulances or police cars which should be managed in the best way, in case of emergency events.

The Fleet Management in practice is being materialized through a Fleet Management System (FMS). The Fleet Management System includes all the necessary equipment and resources for a company or a public body to be able to manage its fleet with the target being to minimize the risks associated with the vehicle investment, improve efficiency, productivity, implement just-in-time and reduce the overall transportation and staff costs. If we associate the above with cost cuttings, in addition to the fact that the cost for a Fleet Management System has been reduced dramatically due to the presence of new technologies, it gives a quick pay back for the investment on a FMS. This is the reason why these systems are becoming very popular recently. A demonstration of the spread of these systems is a market research from the independent analyst firm Berg Insight, which indicates that the number of fleet management units used in commercial fleets in Europe will grow from 1.5 million units in 2009 to 4 million in 2014.

Theoretically, a Fleet Management System tries to solve, every time is needed, a Vehicle Routing Problem (VRP) for a specific set of vehicles that are programmed to serve different customers in different areas with the least cost. Depending on the solution to the VRP, the FMS can be divided into two categories: static and dynamic.

A static Fleet Management System is a system that takes all the information in advance in order to give a solution to the VRP. This means that the customers should be known before the planning process as well as the driving time between customers and the service time at the customers. After the departure of the vehicle(s), no change or improvement could be done to the route.

A definition by Larsen *et al* (2007) of the traditional static VRP is the following:

> *"• All information relevant to the planning of the routes is assumed to be known by the planner before the routing process begins.*
>
> *• Information relevant to the routing does not change after the routes have been constructed."*

The solution to the above problem is being given with a dynamic Fleet Management System which offers a dynamic solution to the VRP. The cooperation of new technologies that provide real-time data to the system using the appropriate algorithm could provide a quick and efficient solution for problems that arise during the time that the fleet is delivering.

A definition by Larsen *et al* (2007) of the dynamic VRP is the following:

> *"• Not all information relevant to the planning of the routes is known by the planner when the routing process begins.*
>
> *• Information can change after the initial routes have been constructed."*

Such a system consists of three major components, the on board technologies and vehicle mobile data terminal, the fleet management system control centre and the mobile and satellite communication infrastructure.

The on board technologies and vehicle mobile data terminal is the hardware that is responsible for the connection between the vehicle and the fleet management centre. It acquires and sends to the control centre various information such as position of the vehicle, speed and condition. The drivers can also upload and send information e.g. cargo delivery status and condition. On the other hand the dispatching centre can send back to the driver, through the terminal, information about new routes or projects/tasks that have to follow and this can be easily read from the terminals screen.

A broad classification of the mobile data terminal and on board devices can be as follows:

1) Mobile travel information devices such as mobile phones, PDAs
2) In-vehicle driver information and navigation systems
3) Devices used to acquire data and transmit them to the mobile data terminal
4) Network of sensors

The fleet management system control centre is responsible for establishing the communication with all the available vehicles (which have to be equipped with a mobile data terminal) and serves as the command centre of the fleet management providing all the necessary information to the users and on the other hand acquiring all the data, storing them in its server/servers and of course analyzing them. Therefore we can say it also provides a bi-directional flow of information between the vehicle and the decision-making centre. It uses the data from the vehicles and with the help of a GIS (Geospatial Information System) Software plots the geographical position of the vehicle followed by the rest of the data acquired usually from satellites through GPS (Global Positioning System).

The control centre system includes all the required hardware (computers, monitors, database servers) and software (commercial software for routing, GIS software, data management software) capable of handling these information and of course the necessary personnel responsible for sending, receiving, analyzing them and also if necessary decision making.

The mean for the communication between the fleet management system control centre and the vehicles is the mobile and satellite communication infrastructure. This includes two parts. One is the mobile access communications network which is responsible for the communication of the control centre with the vehicle data terminal and the latter with the various sensors and micro controllers on board the vehicle. The second is the positioning system (e.g. the GPS) responsible for vehicle tracking.

The recent advances in wireless communications technology have given the users a variety of tools for establishing this connection between the vehicles and the information centers. We can categorize this mobile communication infrastructure in WAN (Wide Area Networks) and PAN (Personal Area Networks). The first case includes technologies such as the Global System for Mobile Communications (GSM), the General Packet Radio Services (GPRS), 3G (Third Generation) and recently 4G. WAN is a network that covers a broad area while on the contrary PAN is a network for interconnecting devices centered around an individual person's workspace. Such a network can be established locally on a vehicle connecting the various sensors and microcontrollers with a “master” device which will be responsible to give the data to the mobile data terminal and therefore to the information centre. Recent PAN communications methods are Bluetooth, Zigbee, RFID (Radio Frequency Identification Technology).

The future of fleet management systems is cybercars and cybernetic transportation. Cybernetic Transportation Systems could be the solution for just in time transportation of goods or people in low cost prices due to lack of personnel for driving and smoother manipulation of the vehicle

A fleet management system can be categorized according to the mode of the vehicles. Therefore we have the following fleet management systems:

a) For Road networks
b) For Railway networks
c) For Marine networks
d) Finally for air networks

In this paper we will deal with the various new technologies which have arisen for the different parts of a fleet management system that can provide a dynamic solution to the VRP regarding road networks. In Chapter 1 we will describe the technologies for the fleet management system control centre, in Chapter 2 for the on board technologies, in Chapter 3 for the mobile communications infrastructure and in Chapter 4 for cybercars and Cybernetic Transportation Systems..

Chapter 1

Fleet Management Systems Control Centre

1. Fleet Management System Control Centre

1.1 Technologies that affect data exchange and processing

- 1.1.1 Electronic Data Interchange (EDI)
- 1.1.2 Push Technology
- 1.1.3 Floating Car Data
- 1.1.4 Application Service Providers
- 1.1.5 Remote Sensing

1.2 Technologies that improve data visualization and area control

- 1.2.1 Geographic Information System (GIS)
- 1.2.2 Geofencing

1.3 Technologies that assist in computational methods and decision making

- 1.3.1 Agent-based Computing
- 1.3.2 Front-End Intelligence

1. Fleet Management System Control Centre

The core of a Fleet Management System is the Fleet management system control centre. If not all, most of the intelligence of the system resides here. The Fleet Management system control centre is responsible for obtaining, processing and distributing information for better use of the system, the infrastructure and the services. In other words it is responsible for communicating with all the vehicles of the fleet, monitoring and tracking vehicle and of course cargo status, dispatching vehicles, analyzing, handling and storing all the received information from vehicles and available information providers. The information that the control centre is handling can be static such as waiting hours, information for specific regulations, holiday information, existing speed limits, expected traffic volumes on specific road sections at specific time periods or even dynamic like congestion, accidents and incidents, road works, weather conditions,. The control centre includes all systems and tools necessary for providing guidance to the vehicles as well as management of the fleet.

The recent years we have witnessed huge progress in the field of computers and microprocessors which has provided us with the ability to handle and process even bigger amounts of data. In the control centre the hardware is necessary to be able to do so and also to store in data servers these data for further process and analysis. The usual systems are connected to local servers for storing huge amounts of data in the system for immediate retrieval if necessary and communicate with outside servers through Internet for collaborating in exchanging information. The major technological steps in the fields of computer software and hardware have given potentials for the control centre in visualizing more accurate, detailed, real-time information and for better control and decision making.

In this Chapter we will refer to some of the new technologies regarding the system’s control centre and their applications. These technologies can be categorized regarding which field of the control centre they can be applied to. Therefore we can categorize them in technologies that a) affect the data exchange and processing, b) improve data visualization and area control and c) assist in computational methods and decision making.

1.1: Technologies that affect data exchange and processing.

As such technologies we consider any new technology that helps the systems control centre to exchange the various information between the systems' parts and furthermore enable it to store and process it in the data servers. Examples of such technologies are the Electronic Data Interchange (EDI), Push Technology, Floating Car Data (FCD), Applications Service Providers (ASPs) and remote sensing.

1.1.1: Electronic Data Interchange (EDI).

EDI can be defined as the transfer of structured data from one computer system to another without any human intervention through the use of agreed standards. Its use has grown rapidly because of the increased demand from customers' side as well as several other benefits: minimization of manual data entry, faster and more accurate transactions, lower communications costs, simplified procedures. The implementation of EDI systems is growing. It has been applied into almost every aspect of the logistical chain (including manufacturing and retailing) and has improved the quality, availability and value of information on almost any part of fleet or cargo movement. Especially in the part of managing a fleet EDI has helped a lot in transmission of information among shippers, carriers and administration officers, in improving communication between dispatchers in control centers and vehicle operators, as well as faster and more accurate data delivery to the planning and monitoring centre of the firm. An example of the desire for better transmission and quality of data is the effort of the six major European manufacturers Daimler AG, MAN AG, Scania, Volvo (incl. Renault), DAF Trucks and IVECO which have developed the Fleet Management Systems Interface (FMS) in 2002. FMS is the effort of those companies to provide a standard interface to vehicle data for commercial vehicles. With the FMS-Standard it is now possible to have manufacturer independent applications and evaluations of the data. The amount of data is dependent on the manufacturer and model of the vehicle and might be different.

1.1.2: Push Technology.

Push Technology is the technology that enables users to request for information from a central server and gain access to it with speed and accuracy. The increased availability of data on the fleet and the fleet management organization has helped implement software solutions that "push" information at any time as fast as possible. Push technology can automatically deliver key management information via e-mail, fax machines, pagers, PDAs and other communication machines. Many Fleet Management organizations use their own Web sites in order to distribute invoices, reservation confirmations.

1.1.3: Floating Car Data.

Floating Car Data is the technology used for using the fleets' vehicles as probes which gather and exchange information between them and then this information are gathered by the control centre in order to create a more accurate, real-time opinion about conditions of the road in order to apply better decision making.

An example of Floating Car Data creating detailed maps is given by Rogers (2000) where the use of vehicles working as probes generates highly accurate maps from the vehicle's position traces. The vehicles will continuously scan the road networks while the control centre of the Fleet management system will collect their traces and process them into digital maps which will be updated all the time. The maps will then be available to the vehicles for use. This proposal has some interesting properties. First of all is truly dynamic since the control centre will receive trace data nonstop all the time and will be able to identify all important events such as traffic jams, car accidents and road hazards. Second this scenario is completely automated. Therefore it makes less necessary hiring digital cartographers or supervisors for the control centre. Also the dangers from human errors are reduced. Third the accuracy of the generated maps is high especially if the control centre receives data for the same road through multiple vehicle passes. Finally the lines plotted on the maps for reflecting lane centerlines will be based upon driver's actual behavior rather than the center of the concrete. Although the system will not be able to replace traditionally cartography it will make an economic and accurate alternative to manual map-making.

A similar research regarding traffic information with Floating Car Data is presented in Schafer *et al* (2002). The paper proposes an alternative approach for analyzing travel time and routes of vehicles in urban roads with the use of FCD using GPS. Here the project was established on a Taxi company. Several hundred of taxis are working as FCD data suppliers. Once every minute each taxi sends data to the control centre of the system where these data are processed the on-line taxi disposition system. The advantages of such a system are that there is no need for additional hardware and software costs and the communication between the vehicles and the control centre is costless since the company uses its existing communication infrastructure. The proposed system includes a client-server based on Java technology. A database management system is used for processing and storing all the positioning data plus different kinds of static data regarding traffic network, identification data for the vehicles etc. The server is connected on line with local information provider for acquiring weather information, events or accidents. Of course it is integrated with a geographic map visualizing different layers of real–time information such as current position and velocity, travel time, warnings for congestions. The system analyzed is a low-cost traffic information system which can be used for real-time data acquisition for inner city applications.

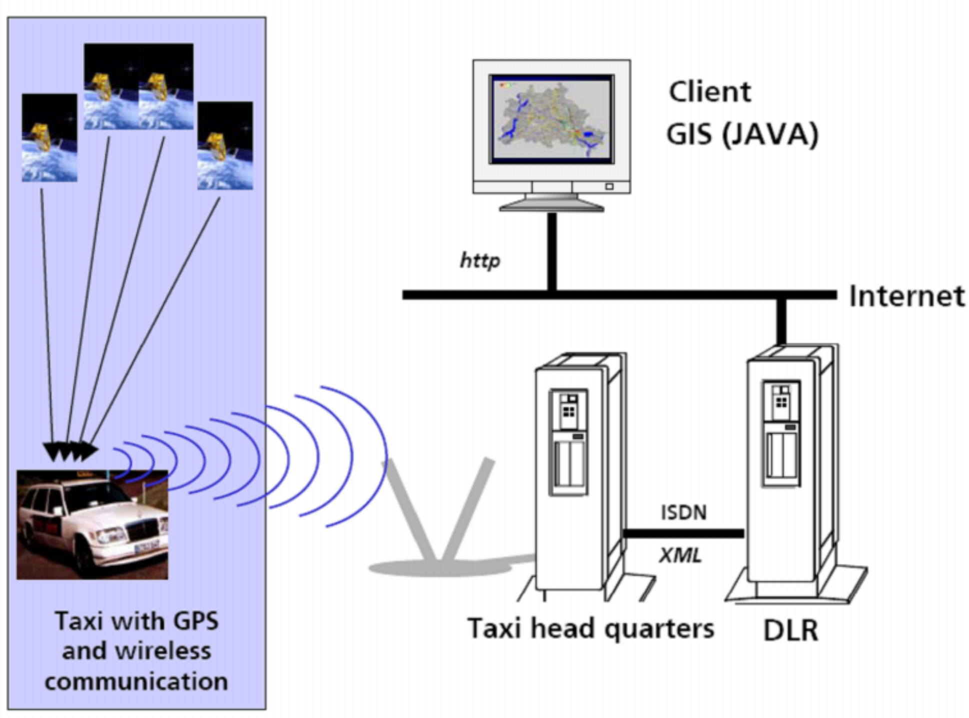


Figure 1.1 Architecture of the traffic Information system (Schafer *et al*, 2002)

Another use of Floating Car Data for real-time traffic information management is shown in Biem *et al* (2010). Their proposal includes appropriate hardware for data streaming computing. The system processes real-time GPS data gathered from taxis and trucks moving in the city of Stockholm, it generates different kinds of real-time traffic statistics and performs customized analysis according to a user defined query. Such customized analyses can include updated measurements for speed and traffic condition for all the different streets of the city, traffic volume measurements by territory, estimation of travel times between two destinations, shortest path routes based on current traffic conditions etc. The key characteristic of this work is the use of stream processing for the purpose of real-time traffic information management. The use of System S research platform that supports high performance stream processing makes this possible. The application was designed to handle GPS data but it is also able to deal with data from other sources like weather data, road incident information, video cameras in order to better estimate and predict traffic conditions.

Liu *et al* (2009) presents another study with the use of Floating Car Data from a Taxi dispatch system for collecting real-time traffic information but in this case the study is referring to the feasibility of the project in an economic point of view.

1.1.4: Application Service Providers.

Application Service Providers "rent" to users applications and other information systems. This technology helps Fleet Management control centers in managing their Fleet from a control point of view. With the use of ASPs it is possible to rent fleet management and other information systems and application software rather than installing them on their terminals as it was accustomed to do. By this way a third party company is responsible for providing to the organization the server platform where the fleet system is included. The servers are located in data centers which provide to the customers continuous availability, security of the information, daily backing up of the data and plenty of bandwidth. All the system users that need to have access to this fleet information can do so from a distance with the use of Internet. There is of course expressed some concern regarding the use of an ASP platform regarding security of the data stored. Nevertheless there exist Internet security technologies and services which are well developed and provided by major industries worldwide. ASP platforms are no less secure than any other network with connection to the Internet. The main advantage of using an ASP platform is that it allows the Fleet management organizations in managing vehicles and equipment and servicing fleet users while at the same time gives the ability to reduce expenses regarding buying, implementing and managing a state of the art technology platform. It is actually a technology that helps the feasibility of a control centre and also provides necessary technology infrastructure especially in medium and small companies the ability to manage the fleet without investing in expensive, heavy equipment.

1.1.5: Remote Sensing.

Remote sensing is acquisition of information of an object, by the use of either recording or real-time sensing device(s) that are wireless, or not in physical contact with the object (e.g. by aircraft, spacecraft, satellite or ship). In practice, remote sensing is the collection through the use of a variety of devices for gathering information on a given object or area. The tracking and surveillance of a mobile object can be done through a number of technologies such as electromagnetic radiation, force fields, acoustic energy and the means for doing so can be cameras, scanners, lasers, radar systems, sonar, thermal devices and other sensing instruments. This information is collected by the control centre enabling to better manage the moving vehicles.

An interesting proposal regarding disaster management systems is given by Mahmood *et al* (2006) where remote sensing technologies are merged with existing fleet management technologies to form an efficient system. This solution proposes an integration of GPS based navigation systems and GIS with remote sensing for providing a well managed disaster management system.

1.2: Technologies that improve data visualization and area control.

Such technologies are helping to visualize better the geographical data by providing maps and coordinates of the desired location and vehicles that must be monitored. Also they assist in managing specific geographical areas by displaying virtual boundaries on a map as long as any object that can be traced inside them. Examples of such technologies are the Geographic Information System (GIS) and Geofencing.

1.2.1: Geographic Information System (GIS).

The Geographic Information System (GIS) is a GUI (Graphical user interface) embedded with appropriate mapping system able to help the users for understanding the exact position of the vehicles in real-time. GIS integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. Therefore, in a general sense, the term describes any information system that integrates, stores, edit, analyzes, shares, and displays geographic information for informing decision making. GIS applications are tools that allow users to create interactive queries (user-created searches), analyze spatial information, edit data, maps, and present the results of all these operations.

The use of GIS has to be integrated with GPS providing an electronic map to the various users. A modern GIS system provides static and dynamic data. Static information includes the necessary road maps and networks while dynamic include any data that is changed regarding to location (e.g. vehicle location) or status (e.g. weather and traffic conditions). In other words in transportation a GIS is an electronic road map, displayed on a graphic screen and powered by the necessary workstations in order to provide to the user the above mentioned information in this one screen.

In a recent paper, Alahakone and Ragavan (2009) propose a general approach for mobile object tracking and navigation by using a GIS module which is based on Google Maps. Google Maps are accessible and available for free on the Internet and provide the usual street maps as well as satellite maps. They use a GPS device and a mobile object database (MOD). For the application of MOD MySQL was chosen as the database storage since it is also open source software (meaning that is available freely on the Internet) and reliable. This system can acquire GPS data from the mobile object including position, speed, time etc. which can be extracted and displayed on the Google Maps GIS module. All the data are saved in the database management system for later reference. The database management system is the bridge between the server and the web application. Apart from storing the acquired positional data it also stores 1) paths assigned in the GIS module for route planning and 2) information for boundaries to restrict the access of mobile objects. The module used has also other features such as route planning, editing and storing. It is also integrated with an SMS module in order to provide SMS alerts regarding the objects data. The proposed system with Google Maps can be used for various mobile tracking applications plus in object navigation systems having much more flexibility than most existing tracking and navigation systems which are concentrated on specific targets.

Another work regarding the GIS software environment is presented in Al-Bayari and Sadoun (2005). They introduce a real-time GIS based Automatic Vehicle Location (AVL) system which integrates the GPS, the GPRS and the SMS technology for providing accurate, flexible and cost-effective way to locate vehicles. Their system is based on GIS objects or controller software. These controllers are inexpensive making it applicable for custom building local tracking system software depending on the exact needs of a client. For more accurate positioning the usual systems apply the GPS data corrections on the car device. In this research they propose an alternative solution by applying the GPS correction at the centralized software. The data of the car's position are broadcasted to the centre's station where the correct position is computed and after the sends it to the car's device via SMS. By this way the car unit does not have to perform large computations. The proposed system is benefited from the functionality of GIS without the need of having to apply complicated GIS programming. This solution is intended to be applied locally and has the advantage of flexibility and cost-reduction.

Interesting information about the two above mentioned technologies is that for the data transfer they both use the National Marine Electronics Association-0183 (NMEA-0183) data format. The NMEA format data has the advantage of having less than 160 characters so is possible to be sent as SMS. Additionally there exists a possibility of an initial validation of the data directly on the arrived NMEA data by checking a single letter (A for valid position and V for not valid) inside the string of the message sent.

1.2.2: Geofencing.

Geofencing is a technology used to monitor objects which are located with the use of GPS. The object sends its geographic coordinates automatically to the control centre while at the same time another set of geographic coordinates creates a virtual boundary (Geofence) regarding a specified geographical area. The control centre is continuous determining whether the moving object is within the geofenced area. If the tracked object is crosses the Geofence an alert is generated.

Among the other applications that Geofencing has it is also applicable in Fleet management. Many professional vehicle fleets (e.g. couriers or public transport vehicles such as police cars) are moving in a specific geographical area for example a neighborhood or a wider area like a city. Geofencing is used to automatically track these vehicles and ensure that they remain in the predetermined boundaries (the Geofence).

The most important Geofencing techniques on roads are presented in Reclus and Drouard (2009). First of all there is the Geofenced area. This technique provides the automatic monitoring of mobile objects around or inside a Geofenced area. The size of the area can vary from a few meters to several kilometers. Coordinates of the characteristic points of the shape of the area are needed to be introduced to the calculation algorithm. Second technique is the Proximity with a point of interest. This technique is used in order to follow a mobile object in relation to a point of interest (POI). The Geofenced area here is actually a circle with the POI at its centre. This technique is the simplest since the computation algorithm needs only the coordinates of the POI and the radius of the circle. Another technique is the Route adherence. Here the mobile object is monitored throughout a journey from the departure point to the final destination. Geofencing is used for ensuring that the vehicle will not deviate from the predefined route. Finally another important technique is Route and Schedule adherence where Geofencing is used for following a mobile object and making sure that it does not alter its predefined route in relation to a given time schedule. In this research some perspectives for the use of Geofencing in Fleet and Freight management on the roads are also presented. It can be used for monitoring and control of restricted areas. This could be quite useful especially for vehicles transporting inflammable or toxic materials or excessively high or heavy vehicles by restricting them to enter Geofenced areas such as tunnels or roads with very steep slopes. This technology could be also used in monitoring of motorway corridors. By this way the tracked vehicles could be monitoring in order to stay in the dedicated road and do not exit until the end of the restricted corridor. Finally another potential use of Geofencing could be in the Service area parking management sector where it could monitor specific areas and available spaces as long as the quality of dangerous goods entering this areas such as hazardous goods vehicles.

1.3: Technologies that assist in computational methods and decision making.

In this category we refer to technologies that improve the computation procedures of the Fleet management system control centre and help to make decisions by simplifying the necessary parameters that affect this process. Examples of such technologies are agent-based computing and by Front-End Intelligent Technology.

1.3.1: Agent-based computing.

Agent-based computing is a technology which is rapidly emerging as a very powerful one in the field of transportation management. An agent-based model (ABM) (also sometimes related to the term multi-agent system or multi-agent simulation) is a class of computational models for simulating the actions and interactions of autonomous agents (both individual or collective entities such as organizations or groups) with a view to assessing their effects on the system as a whole. It combines elements of game theory, complex systems, emergence, computational sociology, multi-agent systems, and evolutionary programming. Monte Carlo Methods are used to introduce randomness. ABM's are also called individual-based models.

According to Chen and Cheng (2010) agents represent the most important new paradigm for software development after object-oriented design. The idea of intelligent agents has found many applications in manufacturing, network management, real-time control systems and transportation systems. For transportation systems the characteristics that make agents so appealing are autonomy, collaboration and reactivity. Agents can do not human intervention and can operate standalone making them proper for implementing automated traffic control and management systems. Agents in a multi-agent system (MAS) can communicate with each other in order to achieve a single target. Agents can also determine external conditions and events and respond to these changes. Agent systems can combine information from multiple detection stations and systems, analyze traffic conditions, respond to traffic flow changes, evaluate real-time traffic flow changes with operational responses. Operations can become more efficient by integrating data from multiple sources while the capability of agents for distributed computing can assist the various stations to cooperate with each other and consequently reduce response time in decision making. Some of the applications that agents can be used are traffic management, urban traffic control, decision support.

Adler and Blue (2002) present a solution approach for roadway management and route guidance based on multi-agent cooperation agents that take place of network managers, information service providers and drivers equipped with route guidance systems. A typical urban transportation roadway system includes the supply-side management, the users, the information service provider and various information sources. The supply-side is made by virtual managers that work together in parallel. They are responsible for collecting and storing data coming from the network, coordinating incident management, and transmitting various travelers' information to the users. In a fully Automated Transportation Management System these managers are computers. The users are the travelers and the vehicles that want to travel through the network and are divided by the mode of travel and their communication connectivity. The information service provider (ISP) provides general buffer storage of information by collecting them from transportation system operators and redistributing them other system operators in the network or other ISPs. The information provided includes real-time traffic condition, yellow pages information, parking information, public transport schedule information etc. ISPs can also assist in giving specific directions to travelers and generate route plans. The various other information sources are some entities that are connected to the network and supply support information such as weather and special events. The proposal of this research is a multi-agent system that replaces all of the above parts of the typical presented network. The proposed approach to traffic management is appealing in many ways. First of all it is able to handle different configurations of drivers, system operators and information service providers (ISPs). Second it enables drivers to maintain control in the process of routing. There exists improved customer support and ISPs can enlarge their customer base. Finally the approach is enabling real-time information acquisition by the ISP on trip planning.

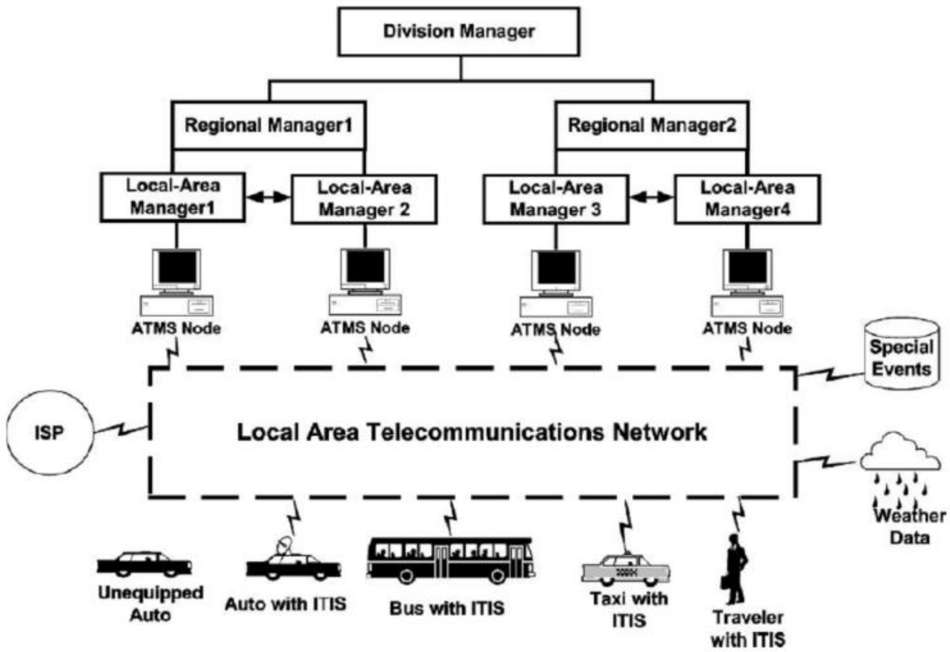


Figure 1.2 Traditional transportation network (Adler and Blue 2002)

Another use of agents is introduced in Seow *et al* (2010) where a multi-agent approach is used for automating a taxi dispatch system in Singapore. The existing system queues the incoming requests at the system's control centre in a first-in first-out way. For each customer request the system chooses between a number of available taxis in the area near the demand and a taxi among them is dispatched after acceptance by the taxi driver if the job. The efficient way of dispatch is assigning the taxi that can take the shortest-path to the pickup location. This is not feasible since it would require a significant amount of computation time. The solution is found by assigning one of the nearest taxis with the shortest straight-line distances to the pickup location. The proposed system in order to improve the service performed by the taxi fleet assign simultaneously and optimally taxis to service all available customer bookings that are made inside a defined time window. By this way the system focuses on the group average customer satisfaction rather than the satisfaction of individual customers. This multi-agent approach uses taxi agents, on behalf of taxi drivers, which can cooperate and take a decision for servicing assignments among the different taxi requests initiated within a time window. By cooperative negotiation several taxi agents can collaboratively search for an assignment solution that they jointly agree. The proposed taxi dispatch system can potentially achieve high efficiency in limiting customer waiting time.

1.3.2: Front-End Intelligence.

Front-End Intelligence (FEI) is a technology equipped with necessary artificial intelligence in order to be able to copy human intelligence in decision making. It can be applied in the control centre in order to replace manual decision-making procedures with artificial intelligence systems that can take decisions based on copied human intelligence.

Thong *et al* (2007) present the use of FEI for Fleet Management Systems. The authors propose a system with high positioning accuracy capable of tracking the target vehicle at areas where GPS signals are weak or unavailable. The targeted vehicles are equipped with terminals powered by Front-End Intelligent Technology (FEI). FEI can succeed faster response, higher accuracy and less dependability on data acquired by a central server. The terminal is connected with the onboard computer of the vehicles.

Chapter 2

On-Board Technologies

2. On Board technologies

2.1: Introduction to Vehicle On-board System (VOS)

2.2: Mobile Data Terminal (MDT)

  2.2.1: MDT description

  2.2.2: An example of a MDT

2.3: Sensors and Sensors Network

  2.3.1: Sensors

  2.3.2: Controller Area Network (CAN)

  2.3.3: A CAN application

  2.3.4: Wireless Sensor Network

  2.3.5: Hybrid systems

2.4: GPS technology on Vehicle

  2.4.1: GPS receiver parts and function

  2.4.2: Description of a GPS receiver in details

2.5: Radio Frequency Identification (RFID)

  2.5.1: Definition of Radio Frequency Identification

  2.5.2: Application of RFID

2.6: Smart mobile phones and PDAs

  2.6.1: Smart mobile phone and PDA description

  2.6.2: Smart phones application

2. On-Board Technologies

The dynamic or real time in the Dynamic Fleet Management Systems can be obtained by acquiring all the necessary information for the vehicle that its route must be optimized. Additionally the driver of the vehicle must have access to this data and to the requests that are given by the control centre. This information of the status of a vehicle is measured with a system of devices that are on board and is communicated to the control centre via mobile and satellite communication systems and is presented to the driver through a user interface. We call this system Vehicle On-board System (VOS) which is using an appropriate Vehicle User Interface (VUI). In the following lines, we will refer to the main technologies which are used on board.

2.1: Introduction to Vehicle On-board System (VOS)

Vehicle On-board System (VOS) consists of the vehicle telematic information devices which collect dynamic data and supports real-time communication, as well as a mobile data terminal for use by the driver. It could also include a wireless sensor network as it is described later in this chapter. The system collects all data for real time monitoring all the parameters which deal with vehicle position, status and cargo information. All this information is transmitted with a selected communication system to the control centre. For the appropriate demonstration to the driver of the real time decisions made by the route planner, the VOS should be equipped with a Vehicle User Interface (VUI). Below are presented the technologies involved in VOS.

2.2: Mobile Data Terminal (MDT)

2.2.1: MDT description

A mobile data terminal (MDT) is an on board computing device for acquiring the data transmitted by the sensors, automates the communication control with the control centre and displays messages and driver interactions. Mobile data terminals feature a screen and a keyboard in order to be established bidirectional communication with the LIS system. The function of the screen is to demonstrate data received by the on board sensors for the status of the vehicle and the cargo, to display the current position of the vehicle with the help of installed maps and to display any messages are send by the control centre. The MDT could be an embedded device or a mobile computer. Is can also be a Personal Digital Assistance (PDA) or even a smart phone, as it is presented below.

2.2.2: An example of a MDT

Kargupta *et al* (2010) presents a vehicle performance data mining system using a patented on board hardware. This system, called MineFleet, analyzes data streams on board the vehicle, generates the analytics, uses wireless networks to send them to a remote server and finally offers them to fleet managers with the use of a web based interface. The basic advantage of the system is that it processes on board the large amount of data obtained by all the vehicle's sensors and transmits only the results to the remote server over the wireless network. This causes a noticeable reduction in the cost use of such programs due to smaller amount of data transmitted via the wireless networks. The mobile data terminal used is a computing device which hosts the software to analyze the data and the interface that connects the vehicle data bus with the computing device. The MineFleet on board module can cooperate with embedded devices, mobile phones and laptops.

2.3: Sensors and Sensors Network

2.3.1: Sensors

A basic device for a Fleet Management System that is placed on a vehicle is a sensor. A sensor is a hardware device which its use is to measure or record the produced response during a change in a physical condition like temperature or pressure. Sensors measure physical data of the parameter to be monitored. The processing of the data is done by a microprocessor which takes as an input a digital signal. The initial signal is a continual analog signal that has been digitalized by an analog to digital converter. The sensors should be connected to sensors networks wired or wireless, which control and gather all the data measured by the sensors.

2.3.2: Controller Area Network (CAN)

An on board wired network that was developed in the 80's for the communication of the Electronic Control Units like microcontrollers and the devices is Controller Area Network (CAN). CAN is a network that is based on messages. Each node of the network can send and receive messages, but not in the same time. Each message has its own priority so the message with the highest priority is finally transmitted. Another issue is that on the CAN network, the devices cannot be connected directly to the bus, but through a CAN controller and a host processor.

2.3.3: A CAN application

A CAN application is stated in Papadoglou and Stipidis (2001) paper where they use a simple system based on a CAN bus, a GPS receiver and the SMS of GSM. A diagram of this system is presented in Figure 2.1.

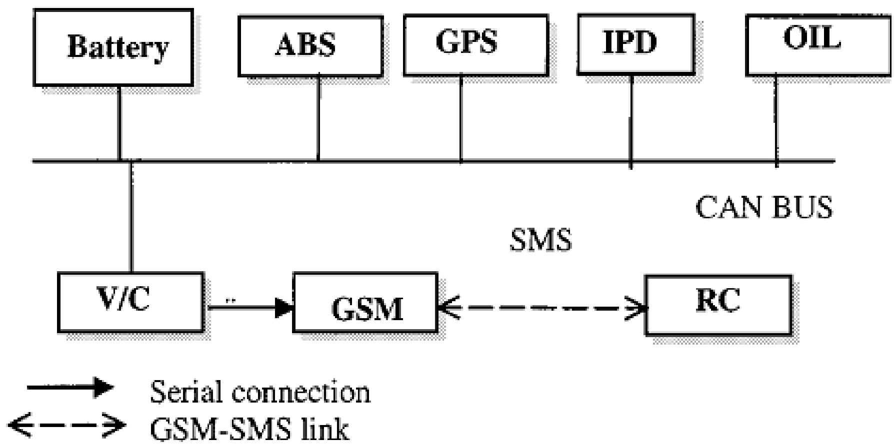


Figure 2.1 Architecture of a system using CAN (Papadoglou and Stipidis, 2001)

The location data which are received by the GPS receiver every second, is being placed on the CAN bus which delivers it to the Vehicle Control. Any additional data for the status of the vehicle such as ABS, battery and oil level or crash sensors are also transmitted to the Vehicle Control. Finally, a message within the Vehicle Control is formed which contains the last two known locations of the vehicle, the velocity of the vehicle, the direction of movement, the GPS universal time coordinated transmitted time and the vehicle identification number.

2.3.4: Wireless Sensor Network

A recent technology system using sensors is the Wireless Sensor Network (WSN) which is a network of wireless sensors, distributed in several parts of the vehicle in order to monitor ambient conditions, such as temperature, pressure, sound, vibration etc. A wireless sensor device is constituted by a microcontroller, a radio module and a sensor or more attached to it. The power supply of the device is usually a long life battery, with a trend to be replaced by solar powered. Each sensor node sends information periodically (in terms of milliseconds) to the Wireless Sensor Network gateway which forwards them to the On Board Computer. The number and type of the sensors in a WSN may vary, depending on the size of the vehicle and the freight. The advantages of a WSN compared to a wired network is the reduced weight which results in fuel savings, easiness in installation and maintenance as well as flexibility in the measuring point.

2.3.5: Hybrid systems

A good example of hybrid systems using CAN and WSN is given in Gutierez *et al* (2010) paper, in which they focus on the use of sensor technology for the monitoring of goods and vehicles. They propose a hybrid system, with a combination of Controller Area Network (CAN) which is already installed on a vehicle, with Wireless Sensor Networks (WSN)s, both resulting in an On Board Computer (OBC) as presented in Figure 2.1.

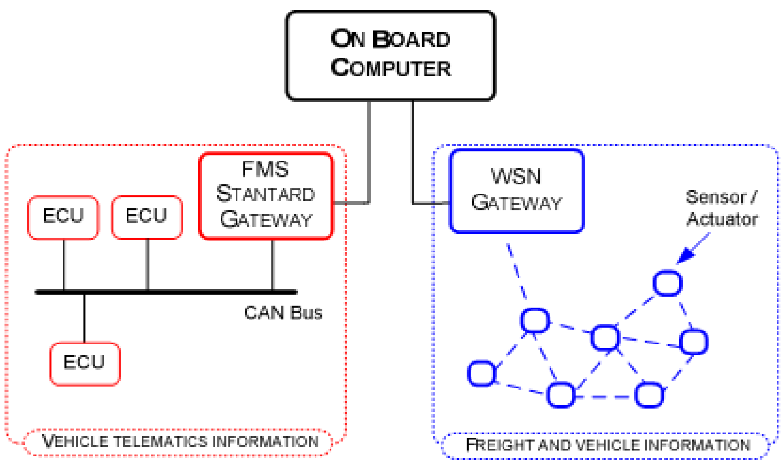


Figure 2.2 Hybrid system using CAN and WSN (Gutierez et al, 2010)

On the CAN bus are attached Electronic Control Units (ECU)s in order to communicate. The bus cannot be connected directly to the internal vehicle bus system due to restrictions by the manufactures, but only to the FMS gateway, which complies with the FMS standard. In the WSNs can be attached truck elements that are not controlled by the CAN. The WSN is composed by several wireless sensor devices and a WSN gateway to connect to the OBC. The WSNs advantage is that they reduce weight, save room in the cockpit and finally reduce costs compared to wired buses. In the proposed system, the WSN was based on Zigbee technology and sensor devices were spread throughout a trailer in order to measure parameters such as temperature, humidity, luminosity, detection of opened doors or trailer coupling operations. For the convenience of the driver, an OBC and a user friendly interface were applied with text to speech capabilities, voice recognition and navigation tools as well as hands free commands for safety reasons. Using the HMI device, the driver will have access to functionalities such as real time schedule changes, displaying incoming orders, vehicle status and monitoring.

2.4: GPS technology on Vehicle

2.4.1: GPS receiver parts and function

In this section we will refer to the GPS receiver as a device placed on a vehicle and not as a Global Navigation Satellite System. Main part of the receiver is the GPS internal antenna which is tuned to the frequencies transmitted by the satellites, a clock and a processor. The GPS device is completed with an interface where the user can place desired location and the receiver can provide directions via text or voice. In the display of the GPS, information of the location and the speed of the vehicle are given, as well as for the existing altimeter. Other information that GPS device can display is information on traffic conditions, information on Points of Interest (POI) such as restaurants, museums, gas stations and Several GPS have a socket for an additional external antenna. Additionally GPS receivers can be connected to a PC in order to upload new maps or to other devices using bluetooth or usb.

A simple GPS function could be given in the following paper by Sterzbach and Haland (1996). Their system that was proposed before 15 years for fleet positioning through GPS is the DuO vehicle tracking system. The DuO was consisted of a Board Unit, a Control Centre and the Communication Network. We will describe in details only the mobile unit. The Board Unit included the GPS receiver and modules for mobile communication and data processing, all enclosed in a robust metal box for protection and electrical shielding. During normal operation, information for the positioning of the vehicle were sent to the Control Centre but also the mobile unit could call the Control Centre if the vehicle was not on a certain position at a specific time. With the appropriate modules, the mobile unit could transfer written messages from the driver to the Control Centre.

2.4.2: Description of a GPS receiver in details

In the following paragraphs, we will describe the GPS receiver in details using a paper. Chadil *et al* (2008) have proposed an open source GPS tracking system by using Google Maps, simple hardware components and open source software. They have named their system Goo-Tracking system. The GPS tracking module is a prototype and uses an 8-bit AVR microcontroller with several peripherals to connect to the modules. These peripherals are a UART driver which connects to the GPS/GPRS module, a SPI driver which connects to the MMC module and 12C driver which connects to the GPIO Control module. The GPS/GPRS module has a double function: it locates the position and then it transmits it to the server. The MMC module stores the position of the device in case of lack of communication and the CPIO Control module can control external devices. The block diagram of the GPS tracking device id presents in Figure 2.2.

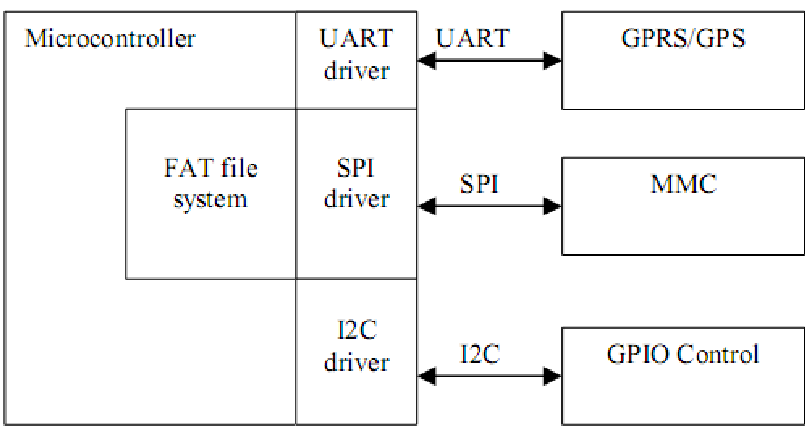


Figure 2.3 Block diagram of GPS Tracking Device (Chadil *et al*, 2008)

During the start up of the GPS module, three main functions are performed by the firmware: the initialization, the location finding and the transmission of the position. In the initialization phase, the firmware is setting the parameters on the microprocessor for UART, SPI and GPIO and on the GPRS/GPS module to warm up the GPS engine and connect to a GPRS network while initializing the storing capability. In the location finding phase, the microcontroller sends an AT+WGPSPOS command, through the UART port, to the GPRS/GPS module. In the third phase, the data are been interpreted showing terms like latitude, longitude, speed, date etc.

2.5: Radio Frequency Identification (RFID)

2.5.1: Definition of Radio Frequency Identification

Radio-frequency identification (RFID) is a data capture technology and wireless identification that can be used in the field of supply chain management and tracking. A RFID system includes transceivers (readers), tags and computer with the appropriate software. A reader consists of a radio interface, an antenna and a control unit which interprets the data received by the tags. A tag is a device that consists of a microchip attached to an antenna and encoded with an ID, which can send and receive, via the antenna, data to and from the receiver. Tags depending on their power supply can be identified as passive or active. The passive tags have no battery and they operate by the filed generated by the reader while the active have their own battery. Some tags can be read from several meters away and beyond the line of sight of the reader. The communication between the reader and the tag is done using radio frequency signals.

2.5.2: Application of RFID

Kalogeras *et al* (2008) proposes a RFID system to monitor the truck freight content. The system includes RFID tags and RFID readers and uses the standard “EPC™ Radio-Frequency Identity Protocols/Class-1 Generation-2 UHF RFID/Protocol for Communications at 860 MHz – 960 MHz Generation 2”. There three possibilities to tag the cargo: tag the palettes, tag the boxes or tag both. The third choice was selected because there is the possibility for boxes to be transported separately. The RFID readers are installed in the interior of the truck in selected points. At the loading or the unloading of any cargo that is tagged on the truck, all data are transmitted to the mobile data terminal. The installation of the readers and their antennas is an important issue which defers from truck to truck and it depends on the storage area of the specific truck. Usually the antennas are installed in the entrance of the compartment.

2.6: Smart mobile phones and PDAs

2.6.1: Smart mobile phone and PDA description

A smart mobile phone is a mobile phone with more advanced capabilities than a conventional one in terms of advanced computing power and connectivity to district or local networks. Smart phones are equipped with large screens that can satisfy a user of a Fleet Management application, have or is added, satisfying amount of memory which can store real time data, can be used as GPS tracking modules and have connectivity features like Bluetooth. Additionally Smart phones use mobile operating systems like Windows Mobile or Android, on which advanced applications can be installed and run. A precursor of the smart phones is actually the personal digital assistant (PDA) and is used as mobile personal computer. It has a strong processor and has various abilities similar to the smart phones. They are equipped with a wide touch screen and can access the internet intranet or extranet using a Wi-Fi or Wireless Wide Area Network. There is also a memory slot for memory expansion and Bluetooth or IrDA for PAN applications.

2.6.2: Smart phones application

In Ghosh *et al* (2007) paper, portable technologies such as smart mobile phones have been used to test the differences in the mobile software architecture between route planning and field, when real time information is used. Smart phones can collect data, store them and communicate them using wireless connectivity. They have advanced computing features which together with the storage capability, allows the installation of demanding programs. Their prototype was based on Java Mobile Edition (J2ME) technology and as a mobile database, they used the file based Record Management System (RMS), which is included in the J2ME package as the underlying database. A series of tests which deal with data based on client orders, run on a generic mobile device simulator in order to identify the average memory usage and the average memory footprint. The basic result is that the efficient design of the user interface in a handheld device is a major issue in the performance to the end-user due to memory constraints.

Chapter 3

Mobile and Satellite Communications Infrastructure

3. Mobile and Satellite Communications Infrastructure

3.1: Mobile Communications Infrastructure

3.1.1: Wide Area Networks (WAN)

3.1.1.1: Global System for Mobile Communications.

3.1.1.2: General Packet Radio Service.

3.1.1.3: 3G.

3.1.1.4: 4G.

3.1.2: Personal Area Networks (PAN)

3.1.2.1: Bluetooth.

3.1.2.2: Zigbee.

3.1.2.3: Radio Frequency Identification.

3.2: Satellites Communication Infrastructure

3.2.1: Global Positioning System

3. Mobile and Satellite Communications Infrastructure

The communication of the vehicles' mobile data terminals with: a) the fleet management system control centre, b) the various sensors and microcontrollers on-board the vehicles and c) the satellites for positioning the vehicles is established through the use of the mobile and satellite communication infrastructure. This communication is actually the transmission of data between the above mentioned parts regarding either information such as condition of vehicle, speed, position or control of the vehicle like arrival of new order, rerouting etc.

The type of this communication is wireless. The term wireless communication is commonly used to describe telecommunications systems witch transfer information without the use of wires. These telecommunications systems (e.g. computer networks, network terminals, radio transmitters and receivers, remote controls etc.) use some form of energy (e.g. radio frequency (RF), infrared light, laser light, visible light, acoustic energy, etc.) to transfer information over both short and long distances.

The recent years the sector of communications has seen tremendous evolution and the steps that have been taken has given us the ability to interconnect devices located even in very long distances with wireless networks. Even the amount of data transmitted and the speed of the transmission have increased dramatically resulting in the possibility to transfer any volume of data in a time frame of minutes. Additionally the mobile and satellites communication infrastructure has seen new technologies arise and improve the way that it transmits the necessary data to the other departments of the fleet management system.

In this section we will first display the subcategories of the mobile and satellite communications infrastructure and then refer to some of the new technologies that have application in the field of fleet management.

The mobile and satellites communications infrastructure can be categorized in two parts. First the part that is responsible for the mobile communications between the hardware of the system itself (e.g. computer terminals of the control centre, microcontrollers on the vehicle) and second in the part for communicating with the satellites for the positioning of the vehicle.

3.1: Mobile Communications Infrastructure.

The mobile Communications Infrastructure is the part that enables the mobile data terminal to connect with the fleet management systems control centre and with all the local devices of the vehicle such as sensors, microcontrollers and encoders. The first part gives the ability to the fleet management control centre to gather all the necessary information from the vehicles (speed, position, mileage, orders finished, condition of the vehicle, condition of the cargo, arrival to destination etc.) in order to be able to manage the fleet from a long distance and additionally to send to the vehicle information from outside sources (such as weather, traffic congestions, road condition, special events) or commands to be executed (new dispatching orders, new routes, end of works, refuel etc.). Usually this connection is established through a computer terminal at the fleet management control centre and after the data is saved in the local server for further processing. The second part allows the vehicle to gather from all the onboard devices at the local network the available data which could refer to fuel consumption, mileage, temperature, condition of cargo, hours of driving, stops made).

Therefore we can categorize the mobile communications part in Wide Area Networks (WAN) and in Personal Area Networks (PAN). WAN is a network that establishes communication in long distances while PAN is a network for connecting devices locally (we can consider such an area the vehicle itself).

3.1.1: Wide Area Networks (WAN).

The Wide Area Network is in other words a broad geographic area coverage data communication computer network. WANs can cover areas such as cities, countries, continents and the whole world. WANs often connect multiple smaller networks, such as local area networks (LANs) together. For example, several major LANs in a city can connect together forming a WAN. When many networks connect together establishing a bigger network (a bigger WAN), the resulting network is called an internetwork, which is generically called to “an internet”. The biggest WAN that exists is “The Internet”. We use the capital I because of this reason. It is the result of the connection of all WANs in the World.

In vehicle fleets a WAN is formed between the vehicles and the control centre and between the vehicles themselves since they operate in a broad geographic area. The data transmission in these formed WANs is achieved through wireless technology, which is data transmission without the use of wires.

The types of wireless technologies which have emerged the latest years and are used in establishing this connection inside the fleets' WAN are GSM, GPRS, EDGE and 3G. In the future the desire for even better types of wireless communication will be satisfied with the development of 4G systems.

3.1.1.1: Global System for Mobile Communications.

GSM (Global System for Mobile Communications) is a global standard for mobile communications. The difference of GSM with similar older technologies is that the signaling and the speech channels are digital. That is why GSM is considered a second generation (2G) mobile phone system. It is also the reason of why it is so widely-spread used by many data communication applications. GSM was also the first mobile standard to use the short message service (SMS), also called text messaging. Another important feature of GSM is that it enables the use of it internationally by roaming arrangements which are made between mobile network operators.

An example of the use of GSM with the SMS feature is presented in a research by Muhammad *et al* (2006) with a two-way multiple tracking system. The system gives the ability of synchronizing the vehicle with the control centre. The communication is done through GSM which receives from a GPS device the data for the position of the vehicle and sends it to the control centre while at the same time it also receives from it information and sends to the vehicle. The mode of transfer is short messaging offered by GSM which makes it attractive and cost efficient. This system gives the possibility of "full duplex communication" or two way communication. That is the communication of the vehicle with the control centre and with other vehicles. There are many possibilities for the application of this system. It can be used as a multi-vehicle tracking device, a fleet monitoring system or even an anti-theft car vehicle security service. Since the communication engine is GSM the tracking can be done internationally with the use of roaming features of the used cellular service provider and the vehicle can be tracked in any GSM-networked country. It can be also used in road and highway safety enforcement since the GPS device can transmit through GSM the vehicle's speed details to the control centre.

In a research presented by Papadoglou and Stipidis (2001) we can see another project which uses the GSM-SMS service in order to provide information to the users with the use of an appropriate GSM-SMS device. The system uses the GSM-SMS network to send the vehicles location and information regarding the status periodically with the use of a GPS device. The implementation of such a system does not need any special infrastructure and that is why it can be cost efficient. The short messages are transmitted in the background through signaling channels which makes the equipment of the system able to be used also for speech transmission if possible. The system provides a real-time two-way communication with the control centre. The position accuracy of the proposed system proves advantageous since even in the worst case scenario the accuracy do not exceed the acceptable errors.

3.1.1.2: General Packet Radio Service.

General Packet Radio Service (GPRS) is applied on the global system for mobile communications (GSM) as a packet oriented mobile data service. GPRS over GSM is sometimes described as 2.5G, meaning that it actually belongs as a technology between the second (2G) and third (3G) generations of mobile telephony. GPRS extended the capabilities of existing GSM implementation by allowing information to be transmitted more quickly, immediately and efficiently across the mobile network. It can provide instant connections using radio coverage without the need of a dial-up modem. The higher data transmission speed allows users to take part in video conferences and interact with multimedia Web sites and similar applications using mobile handheld devices as well as notebook computers. The use of SMS over GPRS can achieve a transmission speed of about 30 SMS messages per minute which is much faster than using the ordinary SMS over GSM, whose SMS transmission speed is about 6 to 10 SMS messages per minute.

An approach of the use of GPRS over GSM network is shown in Chadil *et al* (2008) where a system implementing these technologies is developed with collaboration to a GPS module for acquiring vehicle location and applying transmission of messages. It is actually a vehicle real time tracking system that can be used for fleet planning. The

GPRS operating over the existing GSM networks does not overload the existing network traffic providing data transmission efficiently. The fact that the GSM networks cover a very large area and the GPRS is the largest network for data transmission always on and available makes this approach suitable for the as a real-time tracking management system. The GPS module locates the location of the vehicle and through the GPRS network sends this data to the control centre. Following the fleet operator collects this data and can therefore schedule a plan efficiently. The system can also be used to measure real-time traffic data such as areas with congestion or in emergency situations to report a vehicle position to a rescue fleet operator quickly and automatically.

3.1.1.3: 3G.

3G or 3rd Generation International Mobile Telecommunications is a generations standard for mobile telecommunications providing in a mobile environment wide-area wireless voice telephone, mobile Internet access, video calls and mobile TV. In comparison to older standards 3G provides allows use of speech and data services at the same time with higher rates of transmission and offering greater security over the data transmitted.

In Ghosh *et al* (2007) we can see the implementation of 3g wireless communication technologies for the creation of a system that enables fleet management systems to provide cost effectively accurate, efficient and responsible services. Two of the key areas that can be benefited from such a system are route planning and execution. The system can collect data from the vehicle and compute optimized routes for the vehicles which can help the planners of the fleet to dispatch the appropriate vehicle according to the demands. The ability of the system to do so in real-time enables the fleets' management to dynamically reschedule routes, minimize the time and cost of transportation. The vehicle sends to the control centre with the help of wireless 3g connectivity information regarding position and status where appropriate software constructs the optimized routes. Following the fleet planner can decide based on these optimized decisions the tasks that have to be given to the vehicle and sends back from the control centre route update information for execution. The system supports automatic updates base on the availability of the connection and the changes in status.

3.1.1.4: 4G.

An expected technology which will improve the speed and accuracy in data transmission inside a fleet management system is 4Gm, the successor to 3G and 2G generations of wireless communication standard. It is a standard that is under development and expected to provide a faster and secure mobile telecommunication solution. 4G will allow seamless mobility. By this term we mean the ability of the network to not to interrupt the transfer of a file or data when a terminal moves from one cell (one base station coverage area) to another, but handover is possible. It will also have the possibility the users-devices keep the same IP address while moving, meaning that a mobile server can be reached as long as it is within the coverage area of any server. While maintaining seamless mobility, 4G will offer very high data rates with expectations of 100 Mbits/s wireless services. Due to this increased bandwidth and higher data transmission rates the 4G users will be able to use and share high definition video and the video conferencing features of the devices attached to the 4G network. The 4G wireless system is will provide a telecommunication solution where multimedia applications and services can be delivered to the users “Anytime, Anywhere” with a satisfactory high data rate, premium quality and high security.

3.1.2: Personal Area Networks (PAN).

The Personal Area Network (PAN) is a computer network used for communication between devices such as computers, telephones and personal digital assistants, inside a person’s workspace. The area that is covered with a PAN is typically a few meters. PANs can be used for communication among the devices themselves or for connecting to a higher level network (such as WAN and the Internet). In fleet management systems a PAN is created onboard the vehicle between the mobile data terminal and the various sensors and microcontrollers where the area that is covered from the network is actually the vehicle itself. In order to achieve a wireless personal area network (WLAN) the use of some specific wireless network technologies is necessary. Such technologies include Bluetooth, Zigbee, and RFID.

3.1.2.1: Bluetooth.

Bluetooth is an open wireless technology standard which uses short wavelength radio transmissions for the exchange of data over short distances between fixed and also mobile devices. It creates personal area networks (PANs) whose level of security is high. It can connect several devices without common synchronization problems. The communication established is a master-slave type where one device takes the role of the master and can send data to any other slave device. The roles can be changed at anytime and any device can take the role of the master while the others become slaves.

An application of the Bluetooth communication technology is presented in a paper by Sawant and Tan (2004) where the formation of wireless sensor networks via Bluetooth is used for increasing the safety of road travel. The initial idea that triggered this research was the desire for creation of a complete Autonomous Highway System where vehicles can travel together as groups. The information of the on-board sensors of the vehicles is used in a collaborative network (the vehicles of the network are collaborating by exchanging information) for safety road improvement. These sensors collect important data related to the vehicle, the driver, the passengers, the vehicles environment etc. The research proposes the formation of mobile ad hoc networks with the vehicles. An ad hoc network is a self-configuring network of mobile devices connected by wireless links. Each device in such a network is able to move independently in any direction, and will therefore change its links to other devices frequently. The vehicles on the road will be the ad hoc networks devices that can move freely to any direction and therefore establish links with other vehicles anytime. By this way the vehicles can exchange the information gathered by their sensors and increase the field of view of each one. The communication technology used to form the ad hoc networks is Bluetooth because it the sensors can easily collaborate with Bluetooth hardware and the overall cost is reasonable. The range can be up to 200 meters and the communication established is efficient enough. The structure of Bluetooth communication can support real-time situations like the driving in a highway. Finally each vehicle needs only one sensor for such a system which makes even more cost attractive.

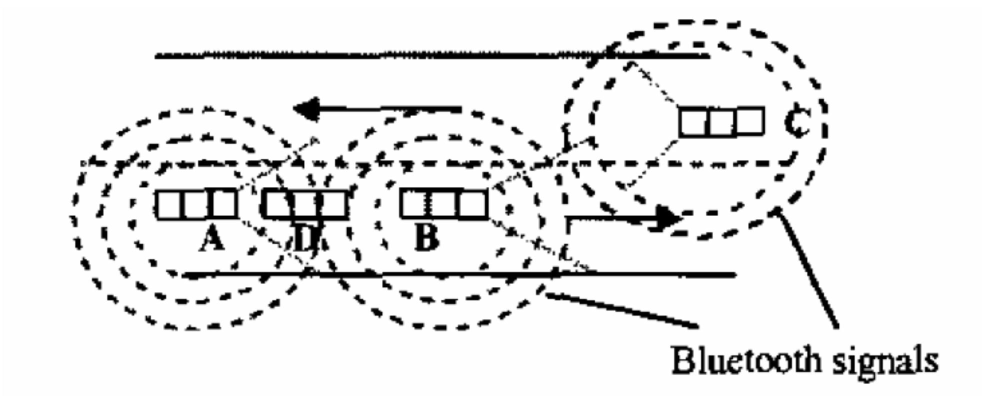


Figure 3.1 Traffic on a rural area (Sawant and Yang 2004)

3.1.2.2: Zigbee.

Zigbee is a communication protocol designed to offer a secure and reliable data communication solution. The intention of Zigbee technology is to be simpler and less expensive than other WPANs, such as Bluetooth. It is ideal for applications that use radio-frequencies (RF) and require a low data rate, long battery life, and secure networking. It has the possibility to become widely spread in wireless communication application because of the low cost. Also the low power-usage allows longer life with smaller batteries. Finally another advantage of Zigbee is its high reliability and more extensive range because of its structure.

One potential use of Zigbee technology is presented by Piorkowski (2010) where an introduction to collaborative transportation applications is presented with the design of two applications for solving traffic congestion and parking problems where the Zigbee is the mean of the short-range wireless communication. Collaborating transportation applications is a term used to describe applications that are based on the collaboration and interaction between vehicles, pedestrians and traffic operators in order to achieve the improvement of the efficiency in travelling in urban areas. So far the solution in solving transportation problems in such cases was collective transportation (e.g. public transportation) which targeted in reducing the number of vehicles on the roads. The two applications are SmartPark and SmartRide. The first tries to collect information about available parking spaces in order to direct drivers to these empty spots while the second uses the available empty seats that are offered by drivers and matches them with pedestrians who want to get to a destination. In the proposed scenario all the necessary information in order to achieve the collaborating transportation is collected and distributed with the combination of the available short-range wireless technologies in order to form an ad hoc network and structure a fully distributable network that enables communication between vehicles, pedestrians and parking sensors. Zigbee is used as such a short-range technology in the development of the proposed applications.

3.1.2.3: Radio Frequency Identification.

Radio frequency Identification (RFID) is a communication technology which is used for identification and tracking by enabling a reader device and an electronic tag attached to an object to exchange data with the use of radio waves.

RFID tags can be categorized in three types: passive RFID tags, active and battery assisted passive. Passive RFID tags have no power supply meaning that in order to operate they need an external electromagnetic field to start signal transmission. Active RFID tags have a battery as a power supply and when they identify an external source (reader) they start to transmit signals. Finally the Battery assisted passive (BAP) RFID tags, also require an external source for initial transmission like passive ones but provide greater transmission range.

Most RFID tags contain at least two parts. The first part is responsible for storing and processing information and the second is an antenna for receiving and transmitting the signal. RFID systems also include a host data system which contains information for the identified items and distributes this information wherever necessary.

An example of an RFID system can be seen in Arebey *et al* (2010) where a solid waste monitoring system is presented. In this system there is collaboration of RFID, GPS, GPRS, GIS and a camera in order to achieve a better responding to customer’s inquiries and calculate the amount of waste in the bin without the involvement of the truck driver. The bins are equipped with RFID tags while the truck carries a RFID reader and a GPS device. The trucks gather through GPS the location information in real time which they send with the help of GPRS to the control centre. The information from the RFID tag and the camera are transmitted to the onboard terminal and from there to the control centre. The control centre can see with the help of appropriate software the exact location of the tracks and manage the fleet. Also the trash bin information which is red by RFID can be seen on screen in the control centre. Instead of gathering all the above information manually with the use of the truck driver everything is done automatically achieving better accuracy in the data, the position and faster response to customers' complaints about uncollected waste and to urgent cases such as truck accidents, long idle times etc.

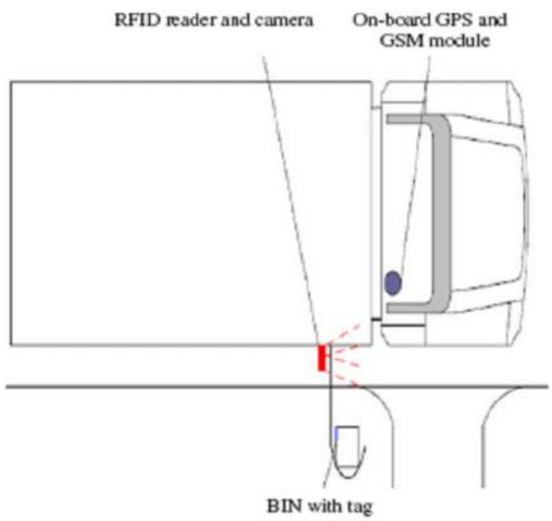


Figure 3.2 BIN with Tag (Arebey *et al* 2010)

3.2: Satellites Communication Infrastructure.

The Satellites Communication Infrastructure is the part of the Mobile and Satellite Communications Infrastructure that enables the communication of the vehicles with the satellites for achieving the positioning of the vehicle. This is done mainly using the Global Positioning System (GPS) with an on board GPS antenna or GPS device although some other technologies have been developed or planned to be developed the latest years such as GLONASS from Russia and Galileo from the European Union.

3.2.1: Global Positioning System.

The Global Positioning System (GPS) is a global navigation satellite system that provides information regarding location and time at any weather condition and time, anywhere on the Earth as long as the point of interest can be seen by at least four or more GPS satellites. It was developed by the United States and now is freely accessible by anyone with a GPS receiver.

Every GPS satellite continually transmits messages which include information about the time the message was transmitted, the precise orbital information and the general system health plus the rough orbits of all GPS satellites.

A GPS receiver can find its position by precisely timing these transmitted signals. It uses the information from these signals to calculate the time each signal did to arrive and then computes the distance to each satellite. These distances along with the satellites' locations are used to calculate the position of the receiver. Many GPS units show additional information such as direction and speed, calculated from position changes of the object with the receiver. The GPS receivers use four or more satellites for obtaining the signals required for calculation in order to minimize errors and achieve higher accuracy.

In Du and Barth (2008) we can see an example of the usage of a GPS system for accurate vehicle positioning on roads at a lane level. This system uses Differential GPS (DGPS) receivers which are low cost and achieve higher accuracy than normal GPS ones. DGPS is an improvement of normal GPS that uses a network of fixed, ground-based stations together with the satellites to improve the accuracy of the positioning. The system proposed can achieve lane-level positioning of vehicles on roads resulting in better fleet management, lane navigation, traffic measurements which are lane-based. The ground base station computer receives data via GPS from satellites and sends back to the vehicles the corrections via wireless communications. It also gathers position information from the vehicles and calculates the lane position. It stores this information on a database and displays the data real time on a map display. The vehicles receive periodic corrections from the base station and at the same time sends back its position, speed and status. The overall system is cost effective and can be used for accurate lane positioning of the vehicles.

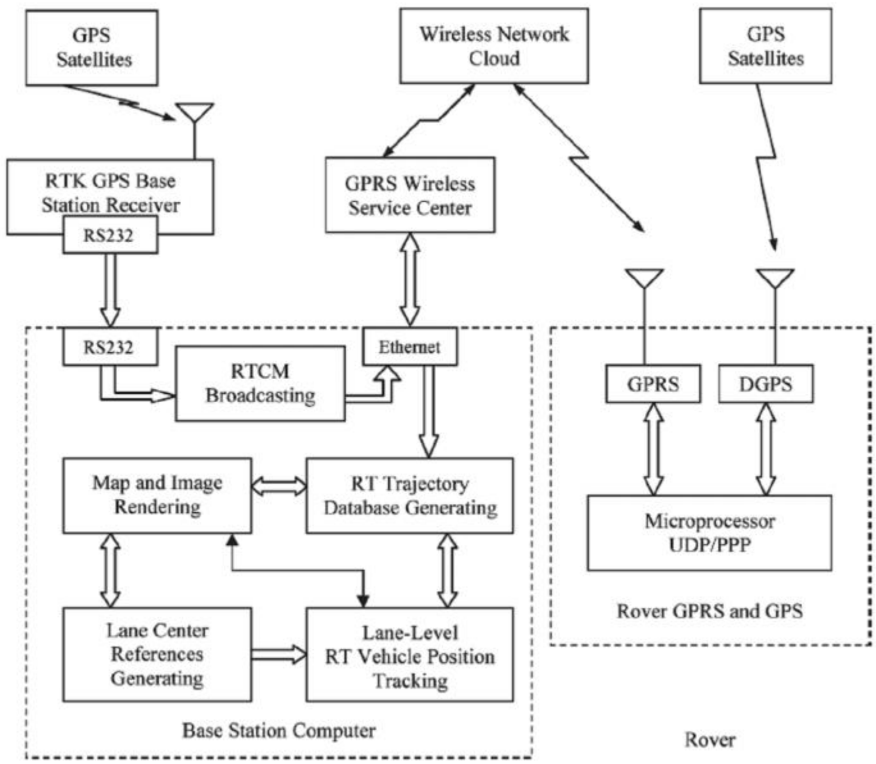


Figure 3.3 System architecture of the lane-level system (Du and Barth 2008)

Another example of a GPS-based system is presented in Meng *et al* (2008) where a test network of GPS reference stations has been used for examining the possibility of achieving accuracies up to a centimeter for the future use of better positioning and tracking of mobile objects. The use of network reference based real time kinematic GPS (NRTK GPS) is introduced which uses a number of reference stations covering a geographical area and forming a network. These stations collaborate and exchange information gathered from their GPS receivers and significantly removes spatial errors from processing this data. The Base NRTK GPS station collects the observation from these reference stations, process them and sends corrections to a rover positioning terminal. This terminal combines its observations with the real-time corrections with the result of positioning with centimeter accuracy. Such implementation of GPS can result in improved applications for future fleet management systems for navigation, driving, lane traffic and even law enforcement.

Chapter 4

Cybercars

4. Cybercars
4.1: Introduction to cybercars
4.2: Description of a cybercar's technology
    4.2.1: Main problems in cybercar technology
    4.2.2: Obstacle avoidance
    4.2.3: Navigation and communication
    4.2.4: Parallel parking
    4.2.5: Platooning
4.3: Dynamic fleet management system for cybernetic transportation

4. Cybercars

4.1: Introduction to cybercars

The future of dynamic fleet management is the development of a fully automated fleet of vehicles or in other words a fleet of cybercars. This fleet of vehicles institutes a Cybernetic Transportation System. CTS could be the solution for just in time transportation of goods or people in low cost prices due to lack of personnel for driving and smoother manipulation of the vehicle. The CTS is being managed by a central control system, which distributes transportation requests or orders in an efficient way and coordinating traffic in a specific environment. For the time being, cybercars are not in the production, notwithstanding that cybercars systems are in operation since the December of 1997 at Schiphol airport. Nevertheless, many R&D programs are running for cybercars supported by the European Union, the US Government and various universities.

4.2: Description of a cybercar's technology

4.2.1: Main problems in cybercar technology

The main problems that the cybercars technology will have to solve are in the areas of controlling the car's mechanics, dealing with the environment with the help of sensors, navigate and deal with the traffic. Parent (2007) states that the hardware for controlling the acceleration, braking and steering is already developed. However the software development is difficult as is system certification.

4.2.2: Obstacle avoidance

Regarding the dealing with environment issue, the main problem is obstacle avoidance particularly in environments where pedestrians and other vehicles go around. Solution is given using ultrasound and sensing bumpers in systems based on scanning laser range finders. The system includes appropriate software for avoidance of collisions and ignore obstacle that are off road. The collision – avoidance system is close to be applied to the automotive industry.

4.2.3: Navigation and communication

For the navigation of cybercars, a navigation system has been developed based on dead reckoning with the use of widely spaced magnets but it can be applied to a small area. In a research level, navigation techniques have been developed using vision systems, lasers or natural environmental features. Finally good communication between vehicles, the control centre and the users is essential for dealing with the traffic. The systems used are already known: GSM and GPRS for users' communication and Wi-Fi for communicating between vehicles and control centre, where is available.

4.2.4: Parallel parking

As stated in Laugier *et al* (1999), the parallel parking is a Sensor Based Manoeuvre (SBM) to park automatically the car in a parking area that is unknown. It has three phases: the finding a sufficient parking place, selecting the appropriate starting point and finally parking the car using the right manoeuvres. In the first phase, the vehicle moves slowly and uses range sensors to detect objects and free spaces in order to create a local map. When the space has found, the control unit computes from the data provided by sensors, the distances from the front car and the back car of the space in order to select an ideal starting point. In the final phase, parking manoeuvres are done by the devices and programs installed for motion control.

4.2.5: Platooning

In platooning, a vehicle can automatically follow another vehicle which it may be automatic or not. This SBM operates in two phases: determining the positioning and the relative velocity and generating the required controls. The determination of the relative velocity and the positioning can be done either using a scanning laser sensor as described above for obstacle avoidance or using a linear camera located in the automatic vehicle and a infrared target located at the rear of the leading car. The leading vehicle is followed by controlling the acceleration or break together with the angular velocity of the steering wheel of the automatic car. In Figure 4.1 is presented a demonstration of platooning.

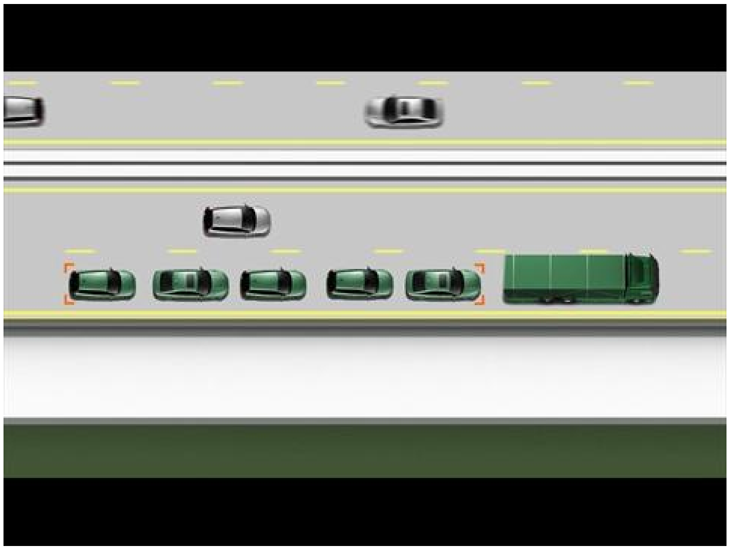


Figure 4.1 Platooning (**https://www.media.volvocars.com**)

4.3: Dynamic fleet management system for cybernetic transportation

Historically, the car sharing system created the need for remote control and driving of the cars, for monitoring as well as for maintenance reasons (when the vehicle stops for unknown reason). The next step of the car sharing system is the automated cars using a Centralized Fleet Management System (CFMS). An example of a Centralized Fleet Management System using cybercars is given by Awasthi et al (2010) for a fleet of small automated vehicles which are serving passengers, using a car sharing system, as a part of the public transportation system. The system proposed uses a message protocol for the communication with cars and the trips are being optimized using as basic criterion the waiting latency of the user. The CFMS is composed of a data base management system (DBMS), a geographic information system (GIS), a reservation and trip management system and a user interface. The architecture of the CFMS is shown in Figure 4.2.

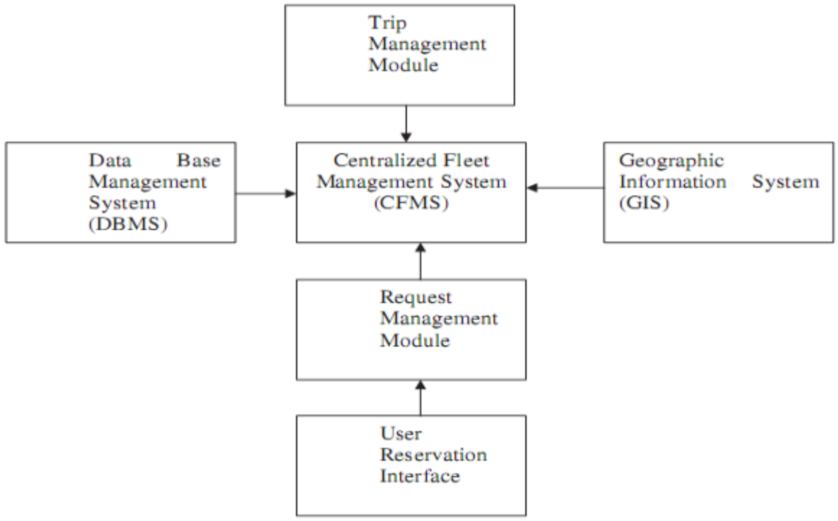


Figure 4.2 Architecture of the CFMS (Awasthi et al 2010)

The trip planning of the CFMS involves the following actions:

- Management of reservation queue
- Route identification and computation of the travel time
- Dynamic traffic information
- Redistribution of empty cars after service completion

For the reservation, the client must use a PDA to send a request to the CFMS, mentioning the pickup station, the drop off station and the time he/she wishes the vehicle to drop by. The CFMS selects a vehicle at the closest distance either free on parking area or driving by from the pickup station. If the request is accepted, then the customer receives a confirmation message containing vehicle id, time and station of pickup. If there is no available car, then the system proposes to the client a vehicle at a different time which can be accepted or rejected.

For the route planning, the CFMS use a routing network which is divided into a number of equal diameter circular clusters. Each cluster has nodes-stations and a parking area equipped with recharging facilities, which is being selected as the location accessible from all nodes at the minimum time. When there is a request, a car moves from the parking area, goes to the pickup station, drives to the drop off station and returns to the parking. An efficient trip of the vehicle is ensured using a chaining strategy by completing a trip with the chaining sub-trips or sub-routes. A sweep heuristic is used to make the sequence of nodes to be visited. Also a pickup and drop off list is created and finally the last node of the pickup list is connected to the first one of the drop off list.

The CFMS also updates in real time, the path of the vehicles according to new customer requests. In order to do this, there is an updated traffic matrix which presents the real time routing of the cars and gives data for vehicle id, status and position, available seats and path assigned. The CFMS additionally dynamically changes the path of the vehicles to avoid deadlocks and queues in the network.

Finally, when there is no client request, the status of the vehicle turns to “idle” and returns back to the nearest parking area, where in case of low battery level, it could be recharged. In case of any other malfunction, the status of the vehicle turns to “breakdown” and is send to the garage area.

Conclusion

In the last years, the freight transportation industry is facing new challenges due to globalization of markets and the need for better and just-in-time services with lower cost. The new technologies that have been developed recently such as satellite positioning, data processing and communication capabilities, have led to the development of fleet management systems. Fleet management systems and especially dynamic fleet management systems have becoming a necessity for transportation companies all over the world. In a report of Berg Insight is stated that the compound annual growth of the fleet management systems till 2014 will be 21.7 percent, beginning from 1.5 million units at the end of 2009 to 4.0 million by 2014. The fleet management market has entered a growth period that will last for several years to come and this is happening because the benefits of such systems are many:

- better control of the vehicle and proper maintenance which leads to cost savings
- client satisfaction due to just in time deliveries
- fuel savings due to optimization of the route
- compliance to the health and safety rules
- compliance to road traffic act
- supervision of driver’s behavior
- vehicle tracking
- control of products’ loading and unloading
- control of the quality of the products

The technologies play a significant role in this bloom of dynamic fleet management systems but there always fields of improvement. Fields of improvement in terms of cost using a dynamic fleet management system, in terms of reliability and continuous flow of information. For example the cost of the data sending via wireless networks is pretty high at the moment. Or the GPS cannot always provide a good signal to the driver. Work must be done towards this direction in order these systems to become more and more popular.

But we believe and we have stated in this paper, that the future is a combination of all these technologies and more to come for the development of a fully automated fleet of vehicles. Cybernetic transportation Systems will give solutions to the problems of urban and goods transportation. In an ideal world with cybercars or cybernetic technology installed to all the vehicles, the transportation time would be dramatically improved since the traffic will be controlled and modified. The transportation cost would be decreased and the delivery time would be eliminated. Before we come to live this situation, we will testify in a few years the invasion of cybercars in car sharing programs assigned to the public transportation and the delivery of incapable people to the homes.

Another area for further research is the area of pervasive and ambient technologies. We believe that it is an area that it will dominate in the upcoming years, not only in the transportation and logistics but in various area of the human activity. It is based on a greater use of tiny sensors and wireless technologies, in order people and vehicles to be connected in a hugely, easy to use, dynamic and powerful information infrastructure. In this direction is targeting speckled computing where Specks are autonomous devices with their own battery and very small dimensions (target is 1 mm^3) which combine sensing, processing and wireless networking. A network of tens or hundreds of specks is called specknet and it can be used to collaborate as programmable computational networks, scattered or sprayed on surfaces or even on a person body.

Development of the above mentioned areas and technologies which take care of health and safety issues, in order to compliance with regulations, can give a boost to dynamic fleet management system and can provide better and cheaper transportations of goods and people.

References:

1) Adler Jeffrey, Blue Victor, (2002) *A Cooperative Multi-Agent Transportation management and Rote Guidance System*, Elsevier Ltd.
2) Al-Bayari Omar, Sadoun Balqies, (2005) *New Centralized Automatic Vehicle Location Communications Software System Under GIS Environment*, International Journal of Communications System
3) Alahakone A.U., ragavan Veera, (2009) *Geospatial Information System for Tracking and Navigation of Mobile Objects*, IEEE International Conference on Advanced Intelligent Mechatronics
4) Arebey ather, Hannan M.A., Basri Hassan, Begum R.A., Huda Abdullah, (2010) *Integrated Technologies for Solid Waste Bin Monitoring System*, Springer Science + Business Media
5) Awasthi Anjali, Chauhan S.S., Parent Michel, Proth Jean-Marie, (2010) *Centralized fleet management system for cybernetic transportation*, Expert Systems with Applications, Elsevier Ltd.
6) Biem Alain, Bouillet Eric, Feng Hanhua, et al (2010) *Real-Time Traffic Information management using Stream Computing*, Bulletin of the IEEE Computer Society Technical Committee and Data Engineering
1) Chadil Noppadol, Apirak Russameesawang, Keeratiwintakorn Phongsak, (2008) *Real-Time Tracking Management System Using GPS, GPRS and Google Earth*, Proceedings of ECTI-CON
2) Chen Bo, Cheng H. Harry, (2010) *A Review of the Applications of Agent Technology in Traffic and Transportation Systems*, IEEE Transactions on Intelligent Transportation Systems, Vol. 11
3) Crainic Teodor, Gendreau Michel, Potvin jean-Yves, (2009) *Intelligent Freight-Transportation Systems: Assessment and the contribution of Operations Research*, Elsevier Ltd.
4) Du Hie, Barth J. Matthew, (2008) *Next-Generation Automated Vehicle Location Systems: Positioning at The Lane Level*, IEEE Transactions on Intelligent Transportation Systems, Vol. 9
5) Giannopoulos G.A., (2004) *The Application of Information and Communication Technologies in Transport*, European Journal of Operational research

6) Ghosh Samik, Nilendu G. Jani, Sajal Das, (2007) *Enabling real-Time Fleet Route Planning and Execution in a Pervasive Transportation Environment. IEEE*

7) Gutierez Veronica, Izaguirre Miquel, Perez Jesus, Munoz Luis, (2010) *Ambient Intelligence in Intermodal Transport Services*, Fourth International Conference on Sensor technologies and Applications

8) Kalogeras A.P., Charatsis K., Mourtos I., Liotopoulos F., Asimakopoulos G., Konstantinopoulos P., (2008) *Integrated real-time system for perishable freight transport management*, IEEE

9) Kargupta Hillol, Sarkar Kakali, Gilligan Michael, (2010) *MineFleet®*: An Overview of a Widely Adopted Distributed Vehicle Performance Data Mining System, KDD'10, July 25–28, 2010, Washington, DC, USA*

10) Laugier C., Paromtchik I., Parent M., (1999) *Developing autonomous maneuvering capabilities for future cars,* IEEE

11) Liu Kai, Yamamoto Toshiyuki, Morikawa Taka, (2009*) Feasibility of Using Taxi Dispatch System as Probes for Collecting Traffic Information*, Journal of Intelligent Transportation Systems

12) Mahmood Farah, Asar Azzam, Mahmood Adnan, (2006) *GPS and Remote Sensing for Emergency Vehicle Navigation and Communication*, IEEE

13) Meng X., Yang L., Aponte J., Hill C., Moore T., Dodson H.A., (2008) *Development of Satellite Based Positioning and Navigation Facilities for Precise ITS Applications*, Proceedings of the 11th International IEEE Conference on Intelligent Transportation Systems

14) Muhammad Ahmad, Javaid Iqbal, Qurat-Ul-Ain, Sumaira Ghazal (2006) *Real Time Fleet Monitoring and Security System using GSM Network*, Proceedings of the 6th WSEAS International Conference on Simulation, Modelling and Optimization, Lisbon, Portugal

15) Papadoglou Nick. Stipidis Elias, (2001) *Investigation for a Global AVL System*, IEEE Transactions on Intelligent Transportation Systems, Vol. 2

16) Parent Michel, (2007) *Advanced urban transport Automation is on the way*, Intelligent Transportation Systems, IEEE Computer Society

17) Piorkowski Michal, (2010) *Collaborative transportation Systems*, IEEE Communications Society

18) Reclus Fabrice, Drouard Kristen, (2009) *Geofencing for Fleet & Freight Management*, IEEE
19) Rogers Seth, (2000) *Creating and Evaluating Highly Accurate Maps With Probe Vehicles*, Proceedings at IEEE Intelligent transportation Systems Conference.
20) Sawant Hemjit, Jindong Tan, ang Qingyan, (2004) *A Sensor Networked Approach for Intelligent Transportation Systems*, Proceedings of IEEE/RSJ International Conference on Intelligent Robots and Systems
21) See Win-Bin, (2007) *Wireless Technologies for Logistic Distribution process*, Emerald Group
22) Seow Kiam, Dang Nam, Lee Der-Hong, (2010) *A Collaborative Multiagent Taxi-Dispatch System*, IEEE Transactions on Automation Science and Engineering
23) Schafer Ralf-Peter, Thiessenhusen Kai, Wagner Peter, (2002) *A Traffic Information System by Means of Real-Time Floating Car-data*, ITS World Congress, Volume m
24) Sterzbach Bernhard, Halang Wolfgang (1996) *A mobile vehicle on-board computing and communication system*, Comput. & Graphics, Vol. 20, No. 4, pp. 659-661, 1996, Elsevier Science Ltd
25) Su Dr., Jun Chuan, (2009) *Effective Mobile Assets Management System Using RFID and ERP Technologies*, International Conference on Communications and Mobile Computing
26) Thong Stephen, Han Chua, Rahman Tharek, (2007) *Intelligent Fleet Management System With Concurrent GPS & GSM Real-Time Positioning Technology*, IEEE
27) Zeimpekis Vasileios, Minis Ioannis, Mamassis Kostas, Giaglis M. George, (2007) *Dynamic management of a delayed delivery vehicle in a city logistics environment*, Dynamic Fleet Management, Springer
28) www.wikipedia.com
29) http://www.berginsight.com/ReportPDF/Summary/bi-fm5-sum.pdf
30) http://www.cybercars.org/
31) https://www.media.volvocars.com/global/enhanced