A Real Time RFID enhanced haulage monitoring system

George Asimakopoulos
Telecom Systems & Networking Department, Technological Educational Institute of Mesolongi,
Nafpaktos, Greece
+30 26340 38566
asim@teimes.gr

Iannis Mourtos
Department of Economics,
University of Patras,
Rion, Greece
+30 2610 969965
imourtos@upatras.gr

Vassilis Triantafillou
Telecom Systems & Networking Department, Technological Educational Institute of Mesolongi,
Nafpaktos, Greece
+30 26340 38566
triantaf@teimes.gr

ABSTRACT

The addition of mobile wireless identification technologies to provide persistent identifiers for food products will become a key mechanism to enhance the consumer experience. This paper presents the use of RFID track and tracing technology to help create a safer and more manageable mobile mean of transporting perishable comestibles with trucks over complicated delivery routes.

This system attempts to integrate conventional fleet management systems with mobile wireless identification technologies in order to enable real time remote management of the food haulage procedure by providing fine grained accurate information for every discrete carried unit, expanding existing systems from vehicle control to unit management.

Categories and Subject Descriptors

B.4.1 [**INPUT/OUTPUT AND DATA COMMUNICATIONS**]: Data Communications Devices.

General Terms

Management, Measurement, Design, Economics, Experimentation, Security, Human Factors, Theory, Legal Aspects.

Keywords

RFID, mobile monitoring, real time logistics management, supply chain management, food transport, food security.

1. INTRODUCTION

In order to manage the food flow through an information flow, key measures in a perishable comestibles haulage management system that should be controlled and monitored are refrigerator temperature [4], unexpected truck stops due to mechanical or road unexpected circumstances, refrigerator failures, faulty deliveries etc [5]. A system that tackles such anomalies at their birth can deal with potential problems that arise from unexpected conditions or when track and tracing in the food supply chain breaks down [5]. The development of networked systems to ensure integrity of data throughout in the supply chain is a key tool to provide full traceability of food products [3].

Taking this work into account, this project tries to build and manage an information flow that corresponds to such critical parameters as they emerge over the haulage process of perishable comestibles. In order to achieve this goal, the project utilizes information regarding both the carriage mean (i.e. a refrigerator truck) and each individual carried good (i.e. food package). Through its functionality it enables haulage companies to monitor and step into the haulage process at all times and conduct correction procedures.

This paper attempts to describe in brief the requirements that the system fulfills and the system architecture that has been formed.

2. SYSTEM SCOPE

The project aims at delivering an automated real time system that enables haulage monitoring for perishable comestibles such as fruits, vegetables, dairy products, wine etc. It attempts to deliver fine grained accurate information regarding every good that is carried during a complex delivery route followed by a truck. This implies that the system must be an integrated system that collects data from various sources that are installed on the truck and on the transferred goods and transfers at all times the data to a central computing system which, stores, analyzes and reports the remotely collected information so that the carrier bares real time knowledge about the entire haulage process in order to react timely to haulage errors and thus achieve cost reduction via error elimination [2].

The system aims at delivering a snapshot of all haulage parameters without human factor interference at all times, thus highlighting haulage errors such as faulty deliveries at the moment they occur, enabling immediate and on sight correction procedures to take place. This way the system tries to replace post haulage error detecting as it happens with conventional systems [1], by inserting error detection and correction procedures into the haulage process, as it rolls [2]. Even more, the system deals in an automated manner with faults that in conventional systems are detectable only via manual procedures such as refrigerator failure and restart that may lead to refreezing and re-freezing, leading thus to major losses regarding product costs, company reputation, legal costs etc [1].

With this system the carrier at all times demonstrates discrete knowledge of the haulage chain that each individual unit has

MOBIMEDIA 2007, August 27-29, Nafpaktos, Greece

DOI 10.4108/ICST.MOBIMEDIA2007.1793

followed during the entire process, because each carried unit is monitored independently regarding loading, unloading, and transfer process steps. The carrier can utilize such information in order to detect faults and monitor the entire haulage process as it is under development, without having to halt monitoring activities until the haulage process has terminated as it usually happens [2].

In general, the system aims at automating haulage monitoring and enabling real time error detection and correction for each and every carried good independently.

3. SYSTEM ARCHITECTURE AND REQUIREMENTS

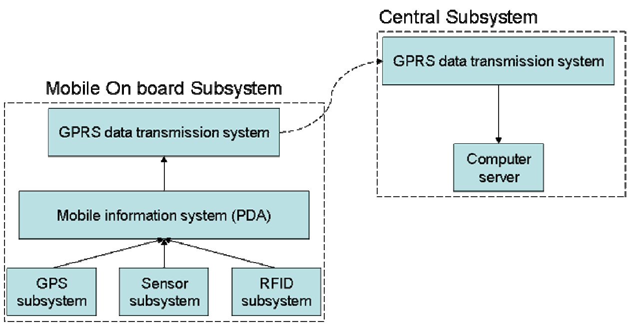

Figure 1. System Architecture

The architecture that the system follows is depicted in the following Figure 1:

3.1 General system requirements

The system produces and transfers approximately 300 Kbytes per truck every day, without any compression techniques. This data load is computed under the estimation that each truck has 5 to 10 sensors that monitor values 2 to 5 times per minute and use 8 bytes per monitored value. This implies that the communication cost of the system is 1 to 3 € per day and truck if GPRS communication is utilized, which is quite cheaper than GSM/SMS solutions. An alternative to GPRS is to use GSM broadband mobile cards.

Regarding data transmission rates, the utilized communication channel must transmit data at least at the rate it is produced. Batch mode can be used in order to minimize telecom costs.

Cryptography algorithms are utilized in order to achieve data integrity and obscurance. Finally, it supports up to 30 vehicles per installation.

A key requirement is cost reduction, as value for money is a key feature the system must demonstrate in order to emerge to a commercial product. At the moment a cost estimation for each installation is at 1.500 € per truck installation. This estimation is based on current market prices for each required module, which implies that this cost will most likely decline in the near future.

Beyond the above mentioned general system requirement documentation, it is composed by the following discrete integrated subsystems, which fulfill the subsystem specific requirements mentioned here.

3.2 Central Subsystem

This subsystem is to be sighted at a central monitoring point, typically at office venues. It is consisted of two subsystems: the GSM/GPRS data transmission subsystem and the central IT server subsystem (Figure 1). The Central subsystem is responsible for collecting, storing, processing and reporting information that is collected by the mobile – on board subsystem.

The GSM/GPRS data transmission subsystem assures communication between the on board subsystem and the IT server subsystem. It is capable of transferring digital data and supports both continuous and batch transferring modes. This system, along with receiving data, transmits data to the on board system, mostly for administration tasks. The IT server subsystem, beyond collecting, storing, processing and reporting information that is collected by the mobile – on board subsystem offers administrative capabilities for on board subsystem administration tasks. This subsystem must be accessible from all loading points so that at the start of each haulage procedure the recipients and the route can be defined. This subsystem stores and processes related data in order to produce a delivery plan that contains information regarding receivers such as location and estimated delivery time. This subsystem also stores and processes information regarding the goods that are to be delivered, such as the number of tags that are loaded on the truck and the proper haulage conditions (i.e. temperature, time to delivery etc). The produced delivery plan is sent to the mobile subsystem that is cited on the truck that will perform the haulage procedure. The IT server subsystem provides the haulage company with real time information about each truck's cargo and the haulage process status. Through this subsystem the company will have real time knowledge of what was delivered to which receiver and when, without having to wait until the truck has returned and the driver has reported the route details. Besides localized information for each carried good, this subsystem supplies information about the hauling procedure and its conditions, such as temperature, refrigerator door opening occurrences, humidity etc. Taking into account that threshold values exist for all measured parameters, this subsystem generates alerts when possible anomalies occur. This subsystem will produce web enabled real time reports so that customers will be able to follow up the goods they are expecting to be transported.

3.3 Mobile on board subsystem

The on board subsystem integrates five different modules: the data transmission system, the mobile information system (PDA), the GPS subsystem, the sensor subsystem and the RFID subsystem (Figure 1). The key concept is that the mobile information system collects, stores and processes data from the other subsystems, thus monitoring in real time every critical parameter. This data is fed to the truck driver and the Central Subsystem via the data transmission system, as appropriate. The mobile subsystem consists of the other subsystems hardware, such as the GPRS data transmission subsystem, various sensors and a PDA.

The RFID subsystem is utilized in order to produce real time information about the truck's cargo at all moments. This subsystem uses RFID readers that are installed on the truck in a way that allows accurate and precise reading of all RFID tags that are placed on the transferred goods on the truck. An RFID tag is associated with each pallet that is loaded onto the truck. Also a tag is associated with each loaded case. In general, the assumption made is that a case is the smallest unit that is carried during the monitored haulage process. Each pallet can carry 60 to 70 cases, and each truck can carry 7 to 30 pallets, depending on its size.

Each time a loading or a landing occurs, the RFID readers scan the truck and report load changes to the mobile information system.

During loading all loaded pallets and cases are recorded via the truck's RFID tag readers. This means that the mobile information system has precisely recorded each loaded good. The recorded goods are then compared with the original haulage plan that has been produced by the central subsystem and has been loaded to the mobile information system via the GPRS transmission system. If disaccording occurs the system raises an alert, otherwise the loading procedure is verified as correct.

During landing all delivered goods are scanned by the truck's RFID card readers. The recorded goods are then compared with the original haulage plan that has been produced by the central subsystem and has been loaded to the mobile information system via the GPRS transmission system.

The GSM/GPRS data transmission subsystem assures communication between the on board subsystem and the IT server subsystem. It is capable of transferring digital data and supports both continuous and batch transferring modes.

The temperature monitoring subsystem utilizes non contact temperature sensors to collect data regarding existing on board temperature conditions. This subsystem utilizes sensors that are placed in a way that accomplishes accurate temperature monitoring. At fixed time intervals the subsystem measures temperature and sends the measured value to the mobile information system. The mobile information subsystem stores each measurement and produces an alert if the monitored temperature doesn't fall into a predefined range. The range is predefined at loading time but can be modified during the haulage process via the central information subsystem.

The humidity monitoring subsystem utilizes humidity sensors to collect data regarding existing on board humidity conditions. This subsystem utilizes sensors that are placed in a way that accomplishes accurate humidity monitoring. At fixed time intervals the subsystem measures humidity and sends the measurement to the mobile information system. The mobile information subsystem stores each measurement and produces an alert if the monitored humidity doesn't fall into a predefined range. The range is predefined at loading time but can be modified during the haulage process via the central information subsystem.

The door opening monitoring subsystem utilizes magnet sensors that constantly check the door status (open or closed) along with the number of times the door has changed status. Each time a door opening occurs it is monitored and reported to the mobile information system, which stores the event information along with time and position data (where and when). The system produces an alert if the status changes are more than expected or if the status changes occur at non predefined places. The proper values are predefined at loading time but can also be modified during the haulage process via the central information subsystem.

The mobile information subsystem is responsible for collecting, storing and processing all data that are produced by the RFID, sensor and GPS subsystems. The mobile information subsystem is loaded with the haulage plan as it has been formed during loading, thus having knowledge of which case or pallet is supposed to be landed at each receiver. The mobile information subsystem conducts all checks and produces all alerts, according to the initial parameters that are loaded into it. The mobile information system is administrated and monitored by the central computer server and it also plays the role of the GPS subsystem in order to reduce cost by abolishing one hardware component.

The mobile information subsystem is independent in the means of offered functionality and utilized data, as it is fully operating even at times that the central subsystem is no operating or inaccessible. The mobile information system also offers data integrity functionality. Typically, the mobile information system is a 2 GHZ Pentium 4 PDA, with 1 GB RAM and a 60 GB HD.

4. FUTURE WORK

In this paper we have presented a project for the design and implementation of a system that aims at enabling real time remote management of the perishable goods haulage procedure by providing fine grained accurate information for every discrete carried unit.

Future work consists of typical testing and assessment of real life pilot installations on trucks through a defined and typical testing procedure, which will lead to experimental results that will refine the system's design and architecture. Future work also involves refining some design issues such as the type of the RFID tags that will be utilized (passive or active), cost reduction per installation and installation time reduction, as system installation implies that a vehicle is put out of operation for some time.

5. ACKNOWLEDGEMENTS

We would like to thank all project team partners for their collaboration and their contribution to our work.

6. REFERENCES

[1] M.S. Reid and M. Serek, "Guide to Food Transport: Controlled Atmosphere", *Mercantila Publishers, Copenhagen, Denmark,* 1999.

[2] Anastasios Semos, Achilleas Kontogeorgos, "HACCP implementation in northern Greece: Food companies' perception of costs and benefits", *British Food Journal,* Vol. 109, Issue 1, pp 5-19, 2007.

[3] Peter Jones, "Networked RFID for use in the Food Chain", *IEEE Conference on Emerging Technologies and Factory Automation, 2006,* Volume, Issue, Sept. 2006 Page(s):1119 - 1124

[4] Kuchta, R.; Stefan, P.; Barton, Z.; Vrba, R.; Sveda, M., "Wireless temperature data logger", *Asian Conference on Sensors and the International Conference on new Techniques in Pharmaceutical and Biomedical Research, 2005* Volume, Issue, 5-7 Sept. 2005 Page(s): 208 – 212

[5] Ding Zhen-hua; Li Jin-tao; Feng Bo, "Radio Frequency Identification in Food Supervision", *9th International Conference on Advanced Communication Technology*, Volume 1, Issue , Feb. 2007 Page(s):542 - 545