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On board system model for road intelligent transport system

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Abstract

In this paper we describe a model to implement on board systems for road passengers transport in the intelligent transport system context. In this model we propose the use of some new technologic advances to achieve a proper integration of the on board information systems, traditionally weakly integrated. This model integrates all the on board elements needed to give us useful information (communications, positioning, sensors devices and ticketing).

1 Introduction

This work belongs to Intelligent Transport System field. Here we describe the information mobile system architecture to install in the buses fleet of a passengers public transport company by road. We can develop it by the use of news elements of the information technologies, specifically: industrial computers, mobile computing and communications infrastructure. Using this architecture we can develop on board information systems that are integrated in the overall company information system in a proper way, García [1]. In this point, we must say that frequently the on board system are less developed than the rest on the information system of the company, this is due to economical and reliability factors. Nowadays the technology offers us products and services that permit us overcome these unsuitable. An illustration of this opinion is the system that we have developed based on this architecture; this system has been installed in a 200 buses fleet. In this paper we describe the architecture by the explanation of the following aspect: first, the design principles (motivations, goals, requirements and technological art state). In second place, we explain the architecture (hardware/software elements and the connexions between them). Finally we resume the main conclusions of the work.

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2 Motivation

The main development goal is to enhance the transport corporation production by improving its on board information mobile systems. Specifically, the aspects to improve are:
- The user service quality.
- The assignation of resources (vehicles and workers)
- The corporation situation in relation with on board system suppliers.
- The technological development possibilities.

The first and second goals can be achieved by the quality information use produced in the fleet on aboard systems. In our opinion, in this context, quality information means information obtained at the time, in the quantity and with the format needed by all the information processes executed in any place of the transport corporation, and the way to achieve it is by properly on board system integration in the corporation information system. Basically, our goal is to obtain all the needed information, originated in the fleet operation, for the decision making short-dated, middle-dated and long-dated. The decision making short-dated is related with the time tables fulfilment and by these decisions we can resolve isolated planning exceptions, middle-dated decision is related with service planning changes (changes in routes, vehicles and drivers assignation, etc.) and long-dated decision is related with the design of the corporation production planning. Nowadays, the action capacity of the companies is limited by the slight information generated in the on board systems, due to the technological limitations of these systems. Our proposal is to improve these systems by using these new technological advances that can support the special environment of the buses. About the last two goals, these can be achieved by using standard technology and design methodologies oriented to open systems.

3 Functionalities and requirements

The architecture must permit the system development with the following capacities:
- It is able to know at every time the time table fulfilment levels.
- It integrates all the devices that can provide useful information .related to: passengers, mechanical , electrical, environment and dynamic.
- It integrates all man-machine interfaces which enhance the driving security and the vehicles comfort.
- It must permit the access to any relevant information generated in on board system by any department of the company in a proper way.

Talking about system requirements, these are the following:
- It must support the special environments conditions producing on board system.
- Economic interest.
- The elements must be connected in order to facilitate on board installation and maintenance.

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- It must use the communications in an efficient way, specially the long distance communications.
- It must be scalable in order to permit the incorporation of new functionalities in a non traumatic way.

4 Technological art state

To apply this architecture to the on board systems, it is necessary that the technology supplies us the needed elements. Fortunately the current technology can give us these elements. Specifically, in our opinion the critic technical elements are the following:

- Industrial computing. It provides the required hardware elements to build systems that can operate with the vehicles special environment conditions (temperature, vibrations, shocks, electrical power, noise, etc). Nowadays, there is a wide offer, but there are two types of industrial specifications that can achieve our requirements: PC-104 system and CompactPCI. The first is a ISA system evolution to industrial environments IEEE [2], this kind of devices can work in a higher temperature range than ISA systems. A second advantage is that the device connexions are more robust, because of the short dimensions of the PC-104 devices and the connector structure. The ComactPCI devices are the newest industrial systems PCI [3] and maybe they are the substitutes of the VME devices (the best from a technological point of view but with a high cost), the CompactPCI devices have suitable characteristic such us: higher temperature range of operation, physical connexion without loose margins and the possibility of hot-swap connexion. But there are two unsuitable: the high price and the short offer of devices.
- Mobile computing. It is an aspect of the information technologies that have been developed very much in the last years and the predictions are that this development will continue with the mobiles communications. To illustrate it, nowadays we have mobile computers with similar capacity of processing and storage than no mobile computer. Some aspects that were being improved are: the storage devices (capacity and reliability), the CPUs (higher processing capacity with less consumption requirements) and wireless communication devices (higher band wide and standard specifications). At present the mobile computer is a technology of wide use, thus the price will be cheaper each time.
- Long distance communication systems, such us mobile telephony and radio systems, offering better services with low prices.
- Vehicles mechanics state integration. Intelligent vehicles are more frequent; these vehicles have systems to control the mechanical and safety, so these systems could inform us about relevant aspects of the vehicle. At present there are specifications standards that permit us to integrate this kind of system, for example CAN bus, Philips [4].

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5 System architecture

It plays a critic role in the system development. The system architecture specifies the elements (hardware and software), the relations and the connexion existing between them, and the techniques and tools used in the development. Assuming this concept about system architecture, we describe our architecture using these topics. From a functional point of view, the system is configured by the following devices or subsystem:

- On board computer. It is the main element and it has access to any device of the system. Basically it is configured by a CPU of low power, 64 Mbytes of main memory, disk to storage all the data and programs (5 Gbytes), PC-104 expansion bus, PC-104/PCMCIA adapter and serial communications ports (RS-232 and RS-485).
- Positioning subsystem. This is configured by all the elements that provide us dynamic information of the vehicle (position, velocity, etc). In our case a GPS receptor and a digital tachometric unit form this subsystem. The GPS provide us a reliable and common time reference for all the vehicles fleet.
- Communication subsystem. It permits us transmitting receiving information from outside (voice and data) and from on board systems (data). The long distance communications are supported by public infrastructure (radio, mobile telephony) or by private infrastructure (normally radio systems), in the case of data long distance transmission, the information travels by short packet of data associated to relevant events. To transmit great amount of data between on board systems and the company information system we use a wireless local net, this element any on board system can be accessed in any place of the corporation.
- Ticketing subsystem. It is configured by the entire element required to pay on board, normally: a driver console and reader/writer magnetic card. This subsystem stores the events associated with passengers movements.
- Sensors subsystem. By these elements the on board system can access to critic parameters related to: mechanicals (for example: oil level, motor temperature, refrigerant liquid level, etc), safety of the vehicle (for example open doors alarm), electrical (for example battery voltage level) or environment (for example temperature).

The connexions schemes deal about the resources, communications specifications and protocols used in the system devices connexions. This aspect is critic in the architecture because it affects to:

- Autonomy level of the different devices and subsystems.
- Complexity and cost of the installation and maintenance of the on board system.
- Data communications reliability.
- New elements integration capacity.

In figure one, we show a connexion scheme between the different elements of the system. We can observe that the connexion topology is a star where the main element is the on board computer. To simplify the connexions and to achieve an autonomous operating of some subsystems, specifically the ticketing subsystem

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and sensors subsystem, we use in these elements an internal multipoint bus, in the case of the ticketing subsystem we achieve it by a RS-485 connexion and in the case of the sensorial subsystem by CAN bus.

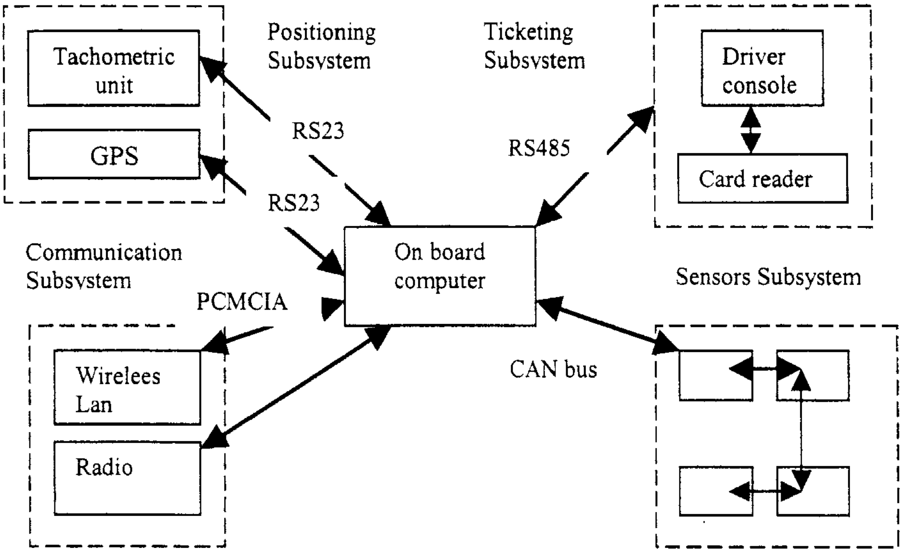

Figure 1: Connexion scheme and subsystems

About software elements to fulfil the specified requirements, like hardware elements, the software plays a critic role. From the on board software point of view the following aspect are important:

- The basic software (operating system). In this point the question is if we choose a proprietary basic software (very common in the technology for road transport) or a wide availability product. Obviously if we want to fulfil the standardization and scalability requirements the option is clear; we must choose a software of wide use. In our development we use a UNIX system for on board computer and for the data communications we use a protocols family TCP/IP.
- Possibility of using free or/and shareware software. Nowadays is a phenomenon which affects the software industry in a critic way. If we use this kind of software the cost of the system decreases substantially. In our case, we use a linux system.
- Design model. Using a wide availability basic software we can use tools and methodologies of design which facilitate fulfilment of the requirements, specifically in our development we applied the hierarchic, Client/Server and object oriented model.

The software structure is developed in a layered way in order to build a modular, flexible and scalable system. The layered structure is configured by three levels: level 0, basic software, it is formed by the operating system and

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basic communication services, level 1, devices abstraction level, responsible of integrating all o board system hardware devices (for example: GPS, mobile radio system, magnetic card reader, user information panels, power and temperature monitor device, etc.) and level 2, applicative server and exceptions monitor, in this layer all the on board specific company processes (applicative server) and the exception monitor (it process all the relevant events) are executed. Figure two shows us this layered design and the relations between levels.

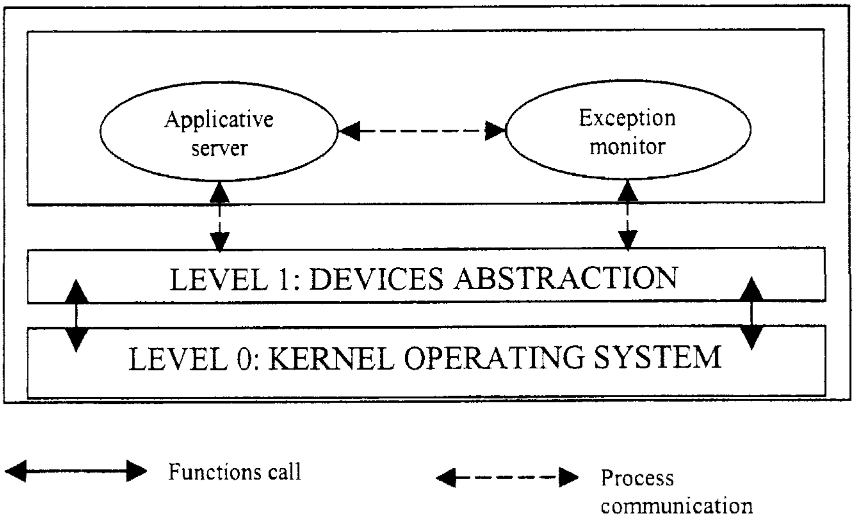

Figure 2: Software design structure

6 Conclusions

At present the new information technologies help us to develop on board system in the context of intelligent systems for a passengers road transport company. These technological advances permit us integrating the mobile information system in the information system of the transport company in a proper way; so we can access to the on board system like any station of the corporation net. We have implemented a architecture for on board system based on some products of the new information technologies, this implementation achieves all the goals describe in Wall [5], these are:

- Company requirements.
- It is integrated properly with other information subsystem of the company.
- The cost is competitive.
- It has a high functionality, usability and scalability.
- It is based on standard technology that will enable reusing the existing design and facilitate competitive purchase.

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Our implementation permits the transport company to improving the service quality and the resources assignment. The architecture explained has been implemented in the Global Salcai-Utinsa transport company (it operates in Gran Canaria, Canary Island, Spain) , this company has a fleet of 300 buses and an annual overage of 17.000.000 of passengers . Actually, our implementation is installed in 200 buses and in the next year will be installed in the complete fleet.

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