Intelligent Transportation Systems with 2.5 and 3 G Mobile Networks

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Abstract: - This paper describes a research project currently ongoing between the University of Salerno and Alcatel Battipaglia in the framework of new services and applications relevant to mobile communications in the near future. It focuses specifically on the study, the characterisation and the implementation of telematic services to be provided by 2.5G and 3G mobile networks in the field of public transportation. The work is organised in three work packages, namely services, architecture and traffic evaluations.

The main services foreseen belong to the following families:
- Fleet management, aiming to the optimisation of the fleet operation. Information related to the fleet are collected, processed and transmitted to a centralised system for further evaluation.
- Services for users both on board and at ground, offering travel facilities both to mobile users (accessing the network via mobile phone), and to residential users. Possible applications are in the field of dynamic timetable, booking, tourist information, etc.

For each of these services, both the user point of view and the network behaviour are analysed with the purpose to identify the interactions between the network entities involved, the information exchanged and the throughput required at the different network levels.

The network architecture is analysed, describing types and motivations for each system or group of systems. In this way a network architecture is outlined, based on 2.5G and 3G mobile systems but also on more traditional fixed networks, with the purpose to cover the different peculiarities of each specific application.

Traffic evaluations are presented for some of the proposed services highlighting the different network resources from a dimensioning point of view.

A pilot application in the Ischia island of the gulf of Naples is also presented. As such an island is characterised by different orographical situations (from flat urban to coasts to mountains), it represents a flexible field trial for the several network entities involved.

Key-Words: - ITS, GSM, GPRS, UMTS, fleet management, end-user services

1 Introduction

Intelligent Transportation System (ITS) is from long ago a matter of study in various organisations (e.g. [1] and [2]) and several important results have been already achieved, from a theoretical point of view. On the other side, several applications have been envisaged. Their actual implementations, however, must face the scenario of current available technologies, not only those conceived at the level of test laboratory, but those effectively deployed in the networks.

The main focus of the present work is to present a number of innovative ITS services which today are feasible thanks to the support of mobile networks as GSM, GPRS and UMTS.

From a general point of view, the project aims to define and study in detail the feasibility of telematic services using in a first phase the GSM-GPRS network and in a second phase the more flexible UMTS environment.

The various research activities have been organised in three work packages devoted, respectively, to services, network architecture and traffic evaluation. A partnership with a mobile operator will allow to test the transport of the related information and the hosting of services applications. A pilot application in the area of the Ischia island (near Naples, Italy) will give the opportunity to verify and refine the results of the research using the fleet of transportation vehicles of the local public transportation company (SEPSA).
**Network Architecture**

The several information that are exchanged to/from vehicle, users and the centralised server farm must be transported by a suitable communication network [3] whose configuration is hereafter shortly outlined. In order to maintain a level of general applicability, several communication means have been considered, namely:

**Vehicle to network:** mainly mobile network, first GSM-GPRS [4] and secondly UMTS; microwave link for short distance, burst and bulk data transfer; GPS for vehicle localization in conjunction with odometers;  
**Within the network:** fixed PSTN-ISDN for low demanding applications located in fixed points; IP packet network for connection between more demanding applications.  
**End-user to network:** mobile access, or fixed network access (for residential user).

**Services**

Starting from the catalogue of services provided by international research groups working on ITS, we provide for each of the proposed services a model of the entities involved in the network, a scenario of the interactions between these entities and details on messages and data exchanged. The services envisaged in this work can be grouped in the following main categories:

**Fleet Management Services**

This family of services is aimed to the management and optimisation of a fleet of vehicles and therefore it is conceived as transparent to the users of the ITS (at least in a first approximation). The services belonging to this group deal with a continuous monitoring of physical parameters of vehicles, as brake wearing, engine maintenance, tyres conditions, etc. The relevant parameters are collected by sensors and possibly undergo a first level of processing by on-board computers. Output data are then sent to a centralised system via a communication channel that can be a mobile packet or switched connection, or a short haul link. The central system performs the final processing on the received data, thus producing the current profile of vehicle conditions that can be used for monitoring purposes or stored for subsequent statistical purposes. The vehicle localisation can be easily performed by integrating a GPS receiver in the equipment on-board. These data are used both for on-board processing and for vehicle tracking by centralised applications. These positioning information allow the development of fleet management services such as the Dynamic Time Table Management and the Dynamic Allocation of Fleet Vehicles.

Clearly the Dynamic Time Table Management service is strictly related to the positioning service when the vehicle is in movement. In fact, the on board GPS receiver, upon receiving the positioning data, performs a comparison with the reference tables, such as arrival and departure schedules for each stop. When a delay is detected, then an exception report is sent from the vehicle to the server farm hosting service applications, and this is repeated until the scheduled time table is matched again. An intelligent transportation system must use fleet resources, as the vehicles, in a way suitable to face sudden increase of passengers on a given transport line (peak demand). The booking information collected by road system at vehicle’s stop are sent to the centralised system in order to assign vehicles to transportation lines accordingly.
The Traffic Monitoring Service allows the realtime supervision of urban traffic conditions along lines. This monitoring can be performed by the Transportation Company itself or by a third organisation. The data collected at road level by counting devices based on cameras or other types of sensors, are processed by means of statistic or deterministic algorithms. When the appropriate elaboration is completed, the centralised system notifies in real time the best path that each transportation vehicle of the fleet can follow at that time. The path optimisation process is also activated when, in the occurrence of exceptional events that may impact the road traffic flow, it is necessary to determine alternative paths in order to respect as much as possible the scheduled time table for each transport line.

Services for passengers at ground
This family of services assists passengers at bus stop or at home. The services at the bus stop can be accessed through the own mobile terminal, via GPRS or UMTS connections, or through fixed terminals located at the bus stop and connected to the central system via PSTN facility (POTS, ISDN-BA or ADSL) or possibly via GPRS-UMTS connection. The same access facilities are available for residential users that access the system from home, using the PC or the mobile terminal. One service that can be requested by this type of user is the transportation map with lines and arrival/departure times at each bus stop, based on information updated in real time. Depending on the request, the system will provide the user with the best path (connection of lines) for his needs, showing also the implied costs. It is also possible to implement an on-line booking service for the lines selected by the user by means of either fixed or mobile terminals (at the bus stop or at home).

Services for passengers on-board
Inside the vehicle, a set of displays are envisaged in order to provide users with real-time information concerning arrival times to next stops, connecting lines etc. These information are received at the vehicle via mobile (GPRS or UMTS) connections.

Traffic related aspects
The service analysis leads to the definition of a model of network entities involved and of their interactions. Starting from some assumptions on the number of users and on the number of accesses to the service in a specified time interval, in is possible to obtain from each scenario an estimate of the traffic generated in the network [5]. This step has a fundamental importance in order to determine the global traffic that the network must sustain in its several nodes, and so to allow the correct dimensioning of the network nodes capable to support the Intelligent Transportation Services. The study of the interactions among the involved network entities must be performed also taking into account the limitations introduced by communication channel. In the future development of this work, we therefore consider to adopt a suitable simulator of the communication channel in order to control the effects of transmission delays and limited bandwidth on the quality of services.

Pilot Project
A field test will allow to refine the study and to stress the HW-SW infrastructure in real conditions. The pilot application of the ITS project will be carried on in the Ischia island, in the Naples bay, where the local public transportation company, SEPSA, will allow to experiment the systems and the services on the own fleet’s vehicles. Within this pilot application, for the sake of simplicity and effectiveness, a limited set of services will be offered, chosen among those more significant and easily feasible. Given the particular island orography, this trial will be an excellent demonstrator, allowing to verify the project’s hypothesis and thus to reinforce the value of the initiative.

Conclusion
The aim of this work is to define services, network architectures and traffic related implications with reference to telematic applications in support of Intelligent Transportation System. A sample group of services has been analysed with specific reference to needs of passengers both on board and at ground, and to services in support to fleet management. Several network options are highlighted in relation to practical application needs. The analysis has been continued with the decomposition of functions in network entities and with the study of their interactions and their needs in terms of data interchange. A pilot application in the Ischia island has been presented and its value as a demonstrator has been highlighted.

References: