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The development of an open platform to test ITS solutions

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Abstract
ITS Platform Northern Denmark is an open platform to test ITS solutions. The platform consists of a newly developed GNSS/GPRS On Board Unit installed in 420 cars, a backend server, and a specially designed digital road map for ITS applications. The platform is open to third-party applications. This paper presents the platform's potential and explains a series of test applications, which have been developed on the platform. The most significant demo applications are an automatic parking payment service, customised traffic dynamic information, a driver log including eco and risk indices, and an interactive traffic statistics application for road authorities. In addition, a number of new projects, which are being planned for the ITS Platform, are introduced.

Keywords
Open Test Platform, Backend Server, Digital Road Map, Demo Application, OBU, FCD

Introduction
The goal is for Intelligent Transportation Systems (ITS) to contribute to making future traffic safer, more efficient and more environmentally friendly. Hence car-to-car as well as car-to-infrastructure communications are needed. In order to achieve these goals, cars should be equipped with wireless positioning and communication technology – an On Board Unit (OBU). At the same time new services and applications should be developed to get road users to install and use the new opportunities and systems. The objective of ITS Platform Northern Denmark (ITS Platform) is to provide a basis for developing systems that give car users intelligent solutions. The platform consists of an OBU installed in 420 cars and enabling the mobile network to communicate with a backend server and WLAN connection with the neighbourhood. The platform has a backend server, OBUs and communication infrastructure. An application thus consists of a number of programs in the OBU/ backend server, Floating Car Data (FCD) provision through backend server, and web/smartphone-based applications as user interfaces.

On Board Unit
The OBU, called InnBox, acts as a liaison between the ITS server, the individual vehicle and the driver. The OBU is a mobile unit, which is installed invisibly in the vehicle, e.g. under the dashboard. When the ignition is turned on, the OBU, among other things, sends the position and speed to the server in real time. These data, called Floating Car Data (FCD), are used for applications, which the driver can make use of. The OBU has been developed especially for mobile ITS services. Dedicated services and applications can run on the OBU through a set of open interfaces. The OBU is easy and inexpensive to install and can be updated with new applications and features via GPRS on a regular basis.

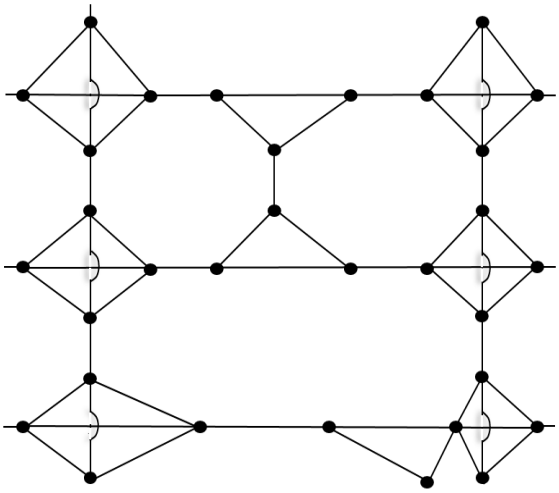
ITS Backend Server
The ITS backend server is the backbone of the ITS Platform. The server collects, processes and transmits FCD, parking data, and traffic information. It is at the centre of the infrastructure, and communicates both with all OBUs via a secured, closed network, Access Point Name (APN), and with the users (i.e. drivers) through secured connections via the Internet or via SMS. The backend server's main task is to be the platform for all applications in the project. It thus ensures that an application can communicate with the OBUs, receive FCD from the cars, and return control messages and other information, if the application requires it. The server keeps track of all cars and users in terms of user rights and services availability. Furthermore, the server keeps track of OBU configurations, the type of software that should be on the device, which applications, the configuration of the basic functionality etc. The server also allows the applications to send e-mails and SMS messages to the users of the applications.

Floating Car Data
Each OBU collects a significant amount of data. With 1 Hz position, direction, speed, and a number of other attributes are collected. In addition, acceleration data are collected with 10 Hz in the driving direction, sideways and vertically, respectively. With 420 vehicles equipped with an OBU the 1 Hz FCD exceed 2 million observations per day, while the number of accelerations in the three directions collected daily exceeds 60 million registrations. FCD are transmitted in real time or almost real time. The latter occurs in cases when map matching is poor or needs more waypoints to improve (see below). The considerable amount of FCD makes special demands on the Backend server in terms of handling these data – demands, which the Backend server is able to meet.

Digital road map
The OBU and the backend server both feature a specially designed digital map of all roads in Region Northern Denmark with a corresponding advanced map matching algorithm (MM) used to link the FCD to the digital map. Furthermore, it is possible to attach attributes, such as speed limits, to the segments contained in the digital map. The basis for the digital map is the Digital Road Centreline theme from the map FOT [1] provided by the Danish Geodata Agency. This map is customised in order to make it more suitable for use in ITS applications. Two maps have been created:

Segment-based map
In case of roads having centre refuge, two parallel road segments have been stored. In addition roundabouts have been registered. Segment- based maps feature nodes indicating where two or more roads meet. Any road segment longer than 1000 m is divided into smaller segments implying that no segments are longer than 1000 m in the reduced map.

Route-based map
In route-based maps, parallel road segments have been merged into one road segment. Also, each roundabout has been merged into a single point. As a novel contribution, nodes are no longer placed where roads meet but exactly between the end points of each road segment. In this way, several road segments run in parallel as road segments are constructed by connecting any two adjacent nodes. For each approach to a 4-way intersection, there are three possibilities: 1: turn left, 2: turn right, 3: straight ahead, i.e. 12 directions are possible. For a 3-way intersection, a total of six routes are possible. See figure 1 for the principles.



Figur 1 Route-based map

An open platform
The ITS Platform is fully open, which means that it can be configured with new test applications as well as update and add new applications in the 420 OBUs online, all on a regular basis. The open platform is available to all public and private companies the only condition being that additional costs must be paid. It is estimated that in this way new ITS applications can be developed and tested for about 20% of the normal cost.

Status on ITS Platform development
In April 2013, the status of the platform developments on the OBU, backend server, applications and digital road map is as follows:

- The OBU is fully developed and has been installed in 420 cars.
- Backend server has been set up and real-time communication with OBUs has been established. Moreover, the domain for uploading new software to OBU over the air has been provided.
- The digital road map and the MM are fully developed on the segment-based map and in the test phase on the route segment map.
- A website has been provided for the users and others interested in ITS Platform [2]
- The demo applications have been implemented or are in the test phase

Demo Applications
As part of the project a number of demo applications to show the platform's potential have been developed/are under development. This section presents the April 2013 status.

Automated parking payment
The parking application is aimed at providing automatic payment when users park at public car parks in the city of Aalborg. A digital map indicating parking areas has been developed, featuring all localities and road sections with parking restrictions. A new state-of-the-art MM to check when a car has stopped in a parking space has been developed and is in a test phase in April 2013. It is expected to be fully implemented by June 2013.

Driving log
The log application is a personal vehicle mileage logbook where the test drivers can get information on the following main functions: 1: Logbook and tracking of vehicle, 2: Eco and 3: Risk Indexes. All parts of the driving log are running.

Logbook and tracking

This application shows online the actual location of the car on a map and generates a tracking-log automatically. All trips are recorded with the times of initiation and completion, starting and ending address, and the time and distance driven. Each driver has access to their logbook on their personal websites.

Eco Index
Eco Index is an application that helps drivers to minimize their fuel consumption in focusing on economical driving. Many modern cars show the current fuel consumption of the car on a display. However, the challenge is that the fuel consumption depends on several factors, on which the driver has no influence: wind, temperature and road grade. Hence, the current consumption is less suited to support the driver in eco driving. One of the objectives of the project was to develop an index that is either independent of the above-mentioned factors or takes them into account. The algorithm for calculating the eco index is described in [3].

Risk Index
This application calculates a risk index on the basis of 10 Hz logging of acceleration (m/s2), deceleration (m/s2), vertical acceleration (m/s2) and speed (km/h). The algorithm for calculating the risk index is described in [3]. The algorithm was developed during an iterative process on the basis of data obtained from test drivers. At the moment we are running a large-scale test to ensure that the variables are set optimally. The algorithm provides the index of a trip showing how aggressively the car has been driven during the trip and the corresponding level of risk. Likewise risk indexes will enable the calculation of various driving style statistics.

Traffic Statistics
The traffic statistics application is a service for the road authorities. FCD will be linked to the route segments in the digital road map (see above for the definition of a route segment). This information then will be used to map congestion-based travel times, congestion levels, delays and velocities. The application is under development. The principles for calculating driving times through the defined route segments are described in [4].

Customized traffic information
This application gives drivers different kinds of traffic information tailored to their individual needs. The application is still under development, but it will give drivers the possibility to request information about traffic problems on a specific road at a specific time of day. Drivers will be able to design their “private” area on a map on their personal web page, for which they want traffic information. The traffic information is based on delays detected by the 420 cars in the ITS Platform. Also, the ITS Platform cooperates with the Danish Road Directorate's Traffic Information Centre and the Danish National Broadcasting Corporation’s traffic portal, and traffic information from these sources will be tailored in a similar way.

ITS projects under test on the ITS platform
Two projects are already using the ITS Platform as a test bed, and others are in the planning stage. Headlines of these projects are:

- Design of communication network performance-measurement collection framework
- Music and road safety

ITS Platform in a European perspective

The ITS Platform has a number of European perspectives: it provides one big-scale test environment in which to test a broad segment of ITS applications. Having full collection of FCD, including positions, a number of risk-related data, and network-monitoring data, the platform is well suited to test e.g. GPS-based road pricing, technical issues regarding E-call, and various usage-based insurances, just to mention a few possible future purposes. Also, the development of advanced dynamic parking payment and customised traffic information applications open the way for increased cooperation within Pan-European research projects such as MOBiNET, where the direct successor of ITS Platform will be an important test site.

Summary

The ITS Platform Northern Denmark project has been developed as an open platform for testing ITS applications on the basis of FCD. The project is in progress and by now, the developed OBU is installed in 420 cars. A number of demo applications for the test platform have been developed to demonstrate the potential of the platform. Moreover, a series of new projects based on the platform are ongoing or planned.

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