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Up-to-date, Real-time Localized ITS Services Provided on a Mobile Platform

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Abstract— **For the Intelligent Transport Systems (ITS) to become mature, the services must reflect the dynamic traffic situation and not be limited to road-construction and other very static traffic events that the commuters experience anyway.**

Today, most of the traffic variation is reported via web-cams, traffic measurement sensors, traffic reporters, but mostly on the major high-ways (E.g, the Traffic Message Channel in Denmark reports only on 3200 locations) as well as predicted as long term variations via e.g. measurements made by companies like Tom Tom.

This means that the information on the traffic situation is almost static, limited and regional based. In order to provide a more accurate and applicable mean for controlling and guiding the traffic flow, either it is necessary to heavily invest in intensifying the reporting units or use a platform that provides the necessary access to an up-to-date infrastructure technology and is carried by lay-mans, like the smart-phones (with GPS receiver, Wi-Fi, Bluetooth, high speed cellular data connection and a large touch screen).

With an 18 month replacement rate [1], and possibilities of combining navigational system, one-to-one communication, broadcast receiver and connection to the mobile platform, the smart phone provides the technologies and power to become the platform to provide and access up-to-date, real time information as requested by the drivers and becomes a central point for networking and coordinated actions.

The purpose of this paper is to provide an example of how to accelerate the roll-out of ITS on a converged technology platform, address relevant interconnecting issues, and relate this to some of the already initiated initiatives with respect to the technology development and the pan-european collaboration. The cross-border focus is needed in order to avoid local based solutions and to avoid proprietary solutions, a support that also shall be supported by political willingness above local level in order to realize the benefit of ITS.

***Keywords*—ITS, Mobile platforms, Smart Phones, Sensor networks, GPS**

I. The ITS Infrastructure

For the ITS to become successful and become a mean to support the road transportation sector, the different ITS related entities like vehicles, road infrastructure, traffic management centers and users must be interconnected by an underlying infrastructure that supports data collection, data handling and information provision.

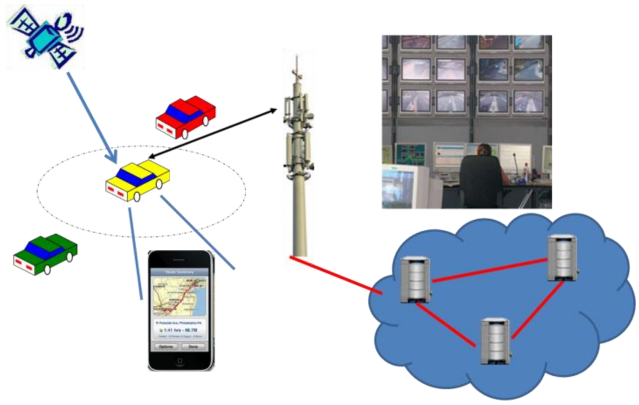

Figure 1: The vehicle as the data collector and information provider.

Every entity in the road infrastructure becomes a source of information, data collector or information receptor:

- The driving unit (car or truck) has a number of sensors to measure road temperature, provide information on actual speed, analyze the surrounding and the traffic ahead, take pre-emptive actions in dangerous situation and so forth. In order for this information to be included in the ITS solution, it must be possible to transfer this data to others (other car or infrastructure)
- The road side infrastructure collects data via sensor about number of vehicles, average speed, picture of the road and so forth, and provides information to the drivers about the traffic situation as well as used for handling emergency incidents
- All data are transmitted to central traffic management center for data crushing and guiding the vehicles in the most efficient way.

This means that all identities must be interconnected somehow in order to get the full benefit of ITS, e.g. by networking the cars makes it possible to warn the vehicles behind about icy roads, traffic jams, or similar situations. By networking the identities provides a platform for new services like intelligent traffic light, where the vehicle is informed when the traffic light is green and whether the current speed enables the driver not to stop [2], [3] (a unnecessary stop for a 40 ton HGV means additional fuel consumption of 0.5 liters [4]). When the vehicle has made a full stop, different vehicle manufacturers, like BMW and Wolkswagen, turns off the engine until the gas pedal is activated (e.g. [5]). Other projects, like the European research project RUNES [6], show examples of how to combine wireless sensor network, RFID and other technologies to provide a platform for informing traffic management centers about truck content and area information for e.g. improved emergency handling.

Interconnecting the identities enables that the information and the guidance information can be generally available on information screen, On-Board Units, smart phones, internet. This requires that the data-collecting units and the infrastructure support the same transmission protocols, like Ethernet and the FMS-standard [7], in order for the different identities to understand and be able to act on the provided information.

The interconnection of identities is not only for data collection, but also to enable cooperation between vehicles and road side infrastructure for efficient handling of the traffic.

One barrier in enabling ITS services is whether the different entities can follow the technological development. A concern is eventually pre-installed on board units (OBU) that are state of the art when the vehicles are produced, but live as long as the vehicles (15 years). Hereby, the capability of the ITS system is limited due to the necessary support of former generation of information platforms, or simply these vehicles are only getting the information for a limited period of time until new technology platforms/standards are replacing the existing ones to provide smarter and more intelligent services.

Recently, it was announced that internet becomes available in the vehicles, like Toyota Entune [8] and hereby opens up for a plethora of new services such find nearest restaurant, gas prices and traffic information. Another service is Renault's app for HGV (Heavy Goods Vehicles) on iPhone providing information on bridge heights, nearest Renault service center, etc. [9].

This seems to be a technology trend that ITS services are provided on a common platform thereby allowing ITS services not only to be developed by the main suppliers, but to be developed by individuals due to the uniqueness of a common market platform like Apples App-store and Android Market.

ITS is not limited to the vehicles, but the vehicles are combining the many information carriers that collect and provide information in the different driving phases: pre-planning, on the road and the post-evaluation. For pre- and post planning, any kind of it-systems with appropriate performance is applicable.

Therefore, the ITS technology in the vehicle may be the limiting factor if ITS should not go back to the current situation where most of the traffic variation is reported via web-cams, traffic measurement sensors and traffic reporters on mostly the major high-ways (E.g., The Traffic Message Channel in Denmark reports only on 3200 locations) as well as predicted as typical traffic load variations over day and week.

Today, most of the information on the traffic situation is almost static, limited and regional based. In order to provide a more accurate and applicable mean for controlling and guiding the traffic flow, either it is necessary to heavily invest in intensifying the reporting units or use a platform that provides the necessary access to an up-to-date infrastructure technology and is carried by lay-mans, like the smart phone.

II. ITS – The technology leadtime. How to become vehicle independent?

In order to be able to continuously collect information and inform the vehicle on the road, it is necessary to provide a mean that can be accessible in any car at any time, and be easily upgradable to support new services and technologies and hence not be dependent on the life-cycle of the vehicle. This means that the platform in the vehicle must be capable of collecting relevant information. Hereby said, the platform must provide information exchange with the environment, and present relevant data in an appropriate way. One platform for this could be the smart-phones. Typically, the smart phone contains a GPS receiver, Wi-Fi, Bluetooth, high speed cellular data connection and a large touch screen. The platform is more than the information device as it provides an efficient interface to the road side infrastructure, but also an interface to the vehicle by interconnecting to interface units or other on-board units [10].

Currently more than 16 % of all phones in Denmark are smart phones and the current sale of smart phones exceeds the number of legacy handsets. This means that more and more drivers has access to a technology platform that can be always on, provide GPS data, and be used for information provision and data collection, data that can be shared by others.

Thereby, the smart phone becomes an interesting alternative to in-built systems in the vehicles and other On-Board Units and thereby being one of the enablers for faster roll-out of ITS systems. It requires, however, that 1) the smart phone user is willing to share collected data with others, 2) that the data can be anonymous, 3) the underlying map-data are accurate and 4) the data models are applicable to extrapolate the collected data to be used for the general traffic situation.

Experiences from the application "pendlerduellen.dk", from the Danish Road Directorate, show that if the benefit, or award, is high enough, there is a willingness among the drivers to send information on speed and location to a central database via their smart phones. The speed can be calculated via the in-built GPS, triangulation in the cellular network, or as alternative via Bluetooth transponders installed along the road-side registering the smart-phones Bluetooth MAC address. Data must, however, be anonymous and not result in fines after post-processing the recorded data.

An up-to-data and accurate map-database is a pre-requisite for successful applications of ITS services as it is the source for all services, being information services, traffic control or road-pricing. With an intensive work on providing accurate map data [11] and the trial project "det digital vejkort" [12], Denmark has the map platform for up-to-date real-time information including temporary construction work, recommended speed, etc. around Copenhagen.

As not all drivers have smart phones, or not all of the smart phone users have activated Bluetooth, it is a necessity that the collected data can be extrapolated for the general traffic flow in order to present a general view on the entire road infrastructure. But it is also known that as the number of smart phones is much higher than the current installations of ITS equipment, the smart phones becomes a better mean to collect significant amount of data and the thereby provide the platform for innovative and intelligent ITS services compared to the existing ITS infrastructure.

Figure 2: ITS is not limited to individuals, but must be available to all for pre-planning, on the road and in the evaluation phase.

This means that there is an applicable technology platform, an accurate map-database and a willingness among the drivers to enable this plethora of new customizable service initiatives like:

- Car-to-car communication via the smart-phone informing others on the up-coming traffic situation, either due to sudden change of speed, or transferring information from external devices like tire sensors and rain-sensors.

- Locally based navigation services taking into account the actual traffic situation for the entire road infrastructure, including also the environmental impact, as well as the information from the navigational guiding systems applied in the vehicles in front. Hereby being able to direct/re-direct the traffic to the most environmental friendly road.

- Provide information on local events / tourists information that can be helpful for the drivers in the exploitation of the environment.

III. THE SMART PHONE – THE SHORT CUT TO FASTER ITS

The different smart phones on the market have certain capabilities that make them useful in the development of ITS applications, see the figure below. Also other characteristics like the life cycle issues count in favor of using the smart phones for ITS applications. These are listed in the following and discussed in details later

- GPS: Smart phones have generally access to the GPS system enabling them as being optimal in application related to navigation and other location aware applications
- Network interfaces: The smart phones have access to a number of network interfaces, including road side units, cellular network and broadcast network, making them ideal in different application scenarios.
- In car sensor networks: To be the ITS device of the future the smart phones should have access to the information from the different sensors implemented in the future cars.
- Life cycle: The life cycle of the smart phones are much faster than cars

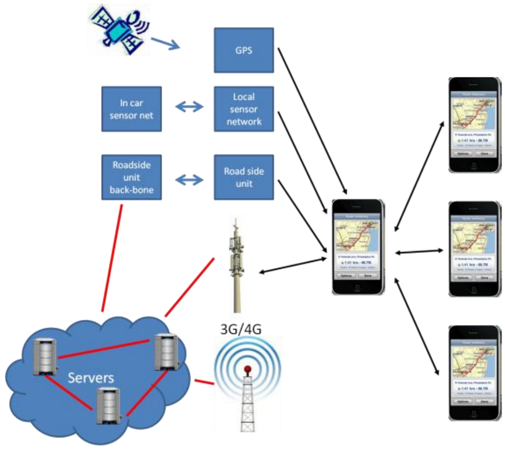

Figure 3: Smart phone and its many interconnecting technologies

GPS

The majority of ITS applications on the market are location aware applications like navigation. Here the GPS enabled smart phones with relatively high quality screens and large local memories are good candidates for provision of location aware applications and services. The smart phones have, apart from GPS connectivity, access to the different mobile and wireless network that enables them to get location information from other sources than GPS. Also when the European GNSS system, Galileo, provides commercial services, it will be much easier to implement new generation of location aware applications based on the new systems on the smart phones rather than upgrading the car hardware/software or changing the cars to new ones which are capable of connecting to the new systems.

Network connectivity

The mobile handset has access to a number of short and long range network technologies that can be used for different ITS application scenarios:

- Short range technologies like Bluetooth and Wi-Fi makes it possible to create ad hoc and opportunistic network between the smart phones in different cars to provide 'car-to-car' and 'car-to-road site' applications on smart phones. This means that the smart phone becomes interface to the different sensors and road-side units, but also the peer-to-peer bridge to other smart phones forwarding and collecting relevant information

- The long range technologies like the connection to the 3G and 4G networks makes it possible for the smart phones to get access to a central server, where from they can get traffic and other relevant information and where to they can deliver local information from the ad hoc and opportunistic networks created on the roads.

- Also many smart phones have access to the broadcast networks like FM radio, DAB and DVB. The traffic and other relevant information are broadcasted via these networks to the handsets and can be included in the ITS applications. In particular the digital broadcast infrastructures have the possibility to deliver local and regional information that are relevant for cars in different specific areas.

In car sensor networks

Some of the ITS applications of the future will be based on sensors implemented in the cars that sense the environment and acquire different context information like the distance to the surrounding cars, the weather conditions like the temperature, humidity, rain etc. It would be highly important that the mobile handsets have access to these information and include them in different ITS applications. A precondition for the widespread success of this will be a high degree of standardization and interoperability between the in car sensor networks and the interfaces implemented in the smart phones.

Life cycle

Obviously the rapid development in the smart phones and the new capabilities for developing new and advanced applications makes the smart phones as optimal ITS device for the cars. Many 'car to car' and 'car to roadside' applications envisioned for the future ITS enabled cars can easily be implemented on the smart phones and get tested on the market. As the smart phone market is fragmented when it comes to the hardware and software capabilities the communication between different applications developed for different platforms available on the market is a big challenge. Hence it is highly important to start pilot projects and implement different ITS applications to be tested using different devices from different manufacturers.

IV. Perspectives for ITS

It is clear that there are two barriers on large scale roll-out for ITS.

First, the companies and municipalities investing in ITS are not the ones that benefit from ITS and realize the revenue from installing ITS. Small scale ITS solutions like navigational units as well as fleet management systems provide a benefit the company. On the opposite, the large scale system that provides the full fledge of ITS solutions requires many different stakeholders with individual business cases, some on private industry level, some on a society level.

The second barrier regards benefitting from the potential of combining IT and telecommunications and apply the right services. Discussions will still have to be taken to identify the relevant services, services that can be provided today using current technologies. Furthermore, it is obvious that the technological convergence must continue, e.g. by providing common interface standards. Figure 3 shows the smart phone in an overall system environment being interconnected to a number of external devices, the interconnection becoming more easier due to the common interface protocols.

In the large scale deployment, none of the system illustrated in Figure 2 must be isolated from others as they all provide the platform for collecting, combining and providing information for efficient ITS services.

V. Conclusions

ITS is the combination of IT, telecommunication and the new innovative services, services that requires that interconnecting infrastructure is dimensioned to handle the capacity and quality demands when offering ITS services, e.g. emergency services with involvement of up to seven different identities that need to be able to access relevant, and sometimes equivalent, information.

The main issue regards communication to the individual vehicles, vehicles that have a number of sensors and represent the actual traffic situation and hereby becomes a source for information. The smart phone was mentioned as the natural information platform in the vehicles due to its short turn-around time of 18 months (compared to the life-cycle of the vehicles of roughly 15 years).

With more and more of all cellular handsets being smart phones, and acquired by lay-men, the mobile platform becomes a mature platform for data collection and information provision for most of the road infrastructure. Thereby, it enables a plethora of new customizable service initiatives for ITS and hence a mean to reduce the impact on the environment from transportation as long the on-going development towards common standards is continued and the political willingness the same.

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