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Sustainable Mobility - possible technical developments in road user charging

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Abstract

This paper presents two possible technical developments in the field of road user charging from a European and especially German perspective. It starts with current and future challenges to sustain individual mobility and it is argued why they are the motivation and reason for further developments. Two approaches for technical development are described.

1. The tolling service is brought to other technical platforms
2. A technical platform, created for tolling can be used for other services

The core of both approaches is to make use of synergies by combining telematics services on existing platforms. The challenges and open questions are discussed.

Keywords: road user charging, tolling

1. Introduction

The evolution of road user charging systems began in the ‘70s when more and more major cities in the world had to face increasing traffic and resulting problems like traffic jams and pollution. The first systems were operated manually and involved personnel in toll booths. Since the mid ‘80s electronic toll collection systems evolved. These systems were mainly based on Dedicated Short Range Communication (DSRC) where a transponder inside the vehicle communicates with roadside equipment while driving on the tolled roads. In the beginning of the 2000s satellite based tolling systems (GNSS – Global Navigation Satellite System) began to evolve. In those systems the usage of a tolled road is determined by the GPS positions received by the device installed in the vehicle. The communication between the in-vehicle device and a backend system is conducted by cellular network (CN) in most cases. The advantage of systems based on the combination of GNSS and CN is that they require fewer infrastructures and equipment at the road side. At the moment DSRC-based and GNSS-based tolling systems coexist.

The objective of this paper is to present possible technical developments in the field of road user charging from a European and especially German perspective. It starts with current and future challenges to sustain individual mobility and it is argued why they are the motivation and reason for further developments. Two approaches for the technical development will be presented and evaluated.

2. Motivation / Economical background for road user charging

In Germany the infrastructure network (road, rail) have been expanded for many years. New roads and rail connections have been built. While building new infrastructure the maintenance and preservation of existing road infrastructure has been neglected. In this field a large amount of pending investments for reconstruction and maintenance has been cumulated over the last years.

On the other hand the earnings designated for building new and maintaining existing road infrastructure remained constant. Fuel tax is the major source for the earnings, at least in Germany. In this regards it must be assumed that earnings from the fuel tax will decrease in future as the overall fuel consumption will decrease further on.1

In 2012 an independent analysis2 attests Germany an annual deficit of 7,2 billion Euro only in the field of maintaining existing infrastructures for the next 15 years. In 2013 this analysis was confirmed and measures how to handle the situation have been elaborated.3 The importance to increase the share of financing which is linked to the infrastructure usage is seen as one major point for the future.

With respect to road traffic this leads to the question how an expansion of road user charging can be accomplished. The earning from road user charging could simply be increased by raising the toll prices. But this approach is limited as the price calculation at least for HGV toll tariffs is regulated and thereby limited by an EC directive.4 Further an expansion can be done in two directions. First it is possible to extend the tolled road network (motorways, national roads, all roads). Second the tolled vehicle categories can be extended (heavy trucks, light trucks, passenger cars).

One thing is most important to achieve for a successful extension of road user charging schemes regardless of the direction (network, vehicles), which is user acceptance. Acceptance among the users is hard to reach as tolling is often directly linked with a negative connotation to be something like pickpocketing. Mobility and the usage of roads is not seen as a service but as a fundamental right which has to be provided for free (at least in Germany).

To increase the acceptance for projects including the introduction or expansion of road charges, it must be made clear that road charging is fair and it creates added value for the user. The perception of

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[1] According to EC law new cars emission have to be reduced to 95g/km until 2020 (Regulation (EC) No *443/2009)*. Further reductions will likely follow.

[2] „Zukunft der Verkehrsinfrastrukturfinanzierung“ / Daehre Kommission, Dezember 2012

[3] „Nachhaltige Verkehrsinfrastrukturfinanzierung“ / Bodewig Kommission, August 2013

[4] **Directive 1999/62/EC of the European Parliament and of the Council on the charging of heavy goods vehicles for the use of certain infrastructures (17 June 1999)**

fairness can be reached by **introducing usage based tolls**. To create added value it must be ensured that the **revenue of road charging remains assigned for the maintenance of road infrastructure** and will thereby improve the individual quality of the mobility of the road user. Another important point is that **tolling must be efficient** which means that after deducting the costs for collection and enforcement a high proportion of the toll revenue shall be left over.

The first two points can only be addressed by creating the framework which is a task for political regulation. The efficiency of road user charging can be optimized by linking tolling with other services in order to create synergies.

The ways how such intelligent links can be achieved will be described further in this paper.

3. Development in tolling

Two ways how the tolling service can be linked with other services related to road traffic in order to create synergies can be distinguished:

1. The tolling service is brought to other technical platforms
2. A technical platform, created for tolling can be used for other services

The two ways are visualized in the following picture:

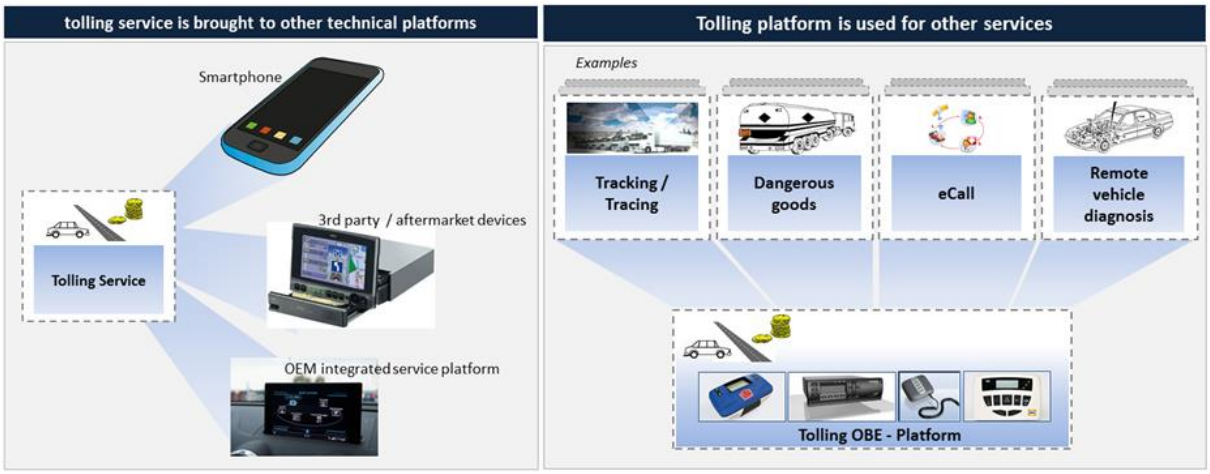

Figure 1- Linking tolling with other services

3.1 Tolling service on other technical platforms

Today electronic toll service providers use proprietary hardware platforms providing their service. This causes high investments as each road user needs to be equipped with a dedicated tag or on-board-equipment (OBE). Taking Germany as example the scenario of introduction of GNSS based tolling for passenger vehicles would mean that almost 44 billion cars would have to be fitted with extra devices. This will unlikely happen as a) the needed investments for the devices and the costs for their distribution would be too high and b) the obligation to install an aftermarket OBE in each vehicle would cause a storm of protest (as it would imply that e.g. in a brand-new German premium

vehicle an external OBE would have to be installed at the windshield or somewhere else).

When thinking about usage based tolling of passenger cars a cost effective and convenient way needs to be found.

One possibility could be to use the driver's smartphone for this service as they are present in daily life and offer a large part of the functionalities which are needed for GNSS based tolling. In principle a smartphone can replace an OBE, as it comes with the needed base functionalities like GNSS-positioning and data communication over cellular network. The existing challenges like missing functions for compliance checking and enforcement and the establishment of a proper platform management with a sound service level management will be discussed later. Another important point to consider is the high penetration of smartphones and its immense annual increase: In many Western countries, the proportion is going to exceed 50% in 2015 at the latest5. In South Korea, being currently the top in smartphone penetration, already three out of four people have a smartphone. China is expected to reach the 50% threshold in 2018.

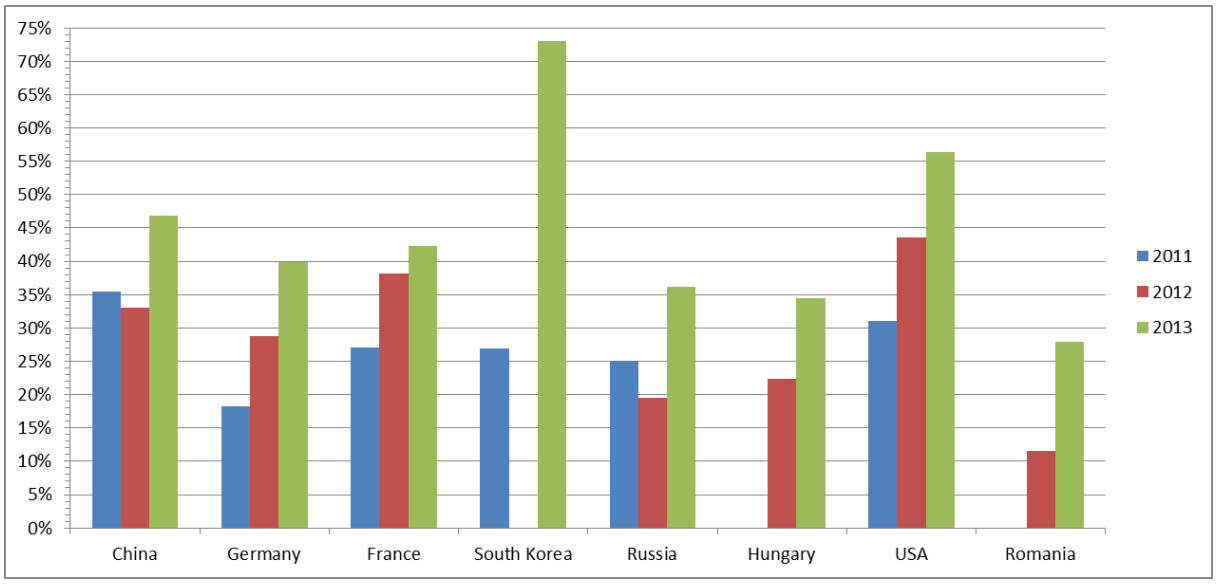

Figure 1 - Smartphone penetration in selected countries (2011- 2013)6

Most of the major car makers are working to find and provide solutions how their vehicles get connected with other vehicles, with roadside equipment and the internet. Numerous technical **in-vehicle platforms** are already implemented that at least connect the vehicle with the internet. Some solutions make use of the functionalities of the smartphones of the passengers and act as an in-vehicle HMI to the smartphone (MirrorLink). Other solutions provide a complete set of functions and applications including cellular connectivity without the need to be linked with a smartphone. The base functionality which is needed for electronic GNSS-based tolling exists in those in-vehicle platforms.

For usage based tolling of passenger cars the application of smartphone based and/or in-vehicle based

[5] http://www.emarketer.com/Article/Worldwide-Smartphone-Usage-Grow-25-2014/1010920

[6] http://think.withgoogle.com/mobileplanet/de/ (19.12.2014)

solutions would be reasonable. Thereby the regulatory question of who is liable to pay toll plays an important role. The smartphone approach might have advantages if the driver is liable to pay the road charges as the device is directly linked to the person (the driver). In-built vehicle platforms may have benefits if the car owner is liable to pay the toll.

3.2 Tolling platform is used for other services

The penetration rate of tolling OBEs among the toll liable vehicles is high, as it comes obligatory by law in most cases. If a tolling platform is opened to enable the usage by additional services the benefits are both on side of the toll service provider as some of the costs can be remunerated and the utilization rate of its hardware can be increased which leads to a higher cost-efficiency of its platform. The provider of additional services can benefit from reduced costs for hardware, reduced costs for installation and maintenance and from the high operational requirements that the tolling platform has to fulfill to meet the existing financial risks in the tolling business. The end-user can benefit by getting the services offered at a lower price assuming that the provider passes part of its cost saving to the end-user.

In GNSS tolling systems the platform provides the base functionalities like GNSS-positioning and secured data communication over cellular network which are needed for numerous value added services like e.g. tracking and tracing of vehicles. Furthermore data transmission via DSRC is possible, which enables e.g. services like automatic gate control where vehicles are automatically identified to control the access to restricted areas.

When value added services make use of the functionalities provided by the tolling platform they could be designed and engineered on a very lean basis. It might be possible that a tracking/tracing service does not necessarily need dedicated hardware in the vehicle.

The approach to use a GNSS tolling platform is theoretically possible whenever a dedicated platform for tolling is brought into the vehicle. Up to now this only happened with respect to tolling of heavy goods vehicles. Examples are the tolling systems in Germany, Slovakia, Switzerland and the foreseen tolling system on national roads in France.

4. Challenges

Naturally there exist a number of challenges and open questions that have to be addressed and solved. Some challenges can be assigned to both approaches and some are specific for each of the approaches.

4.1 Challenges for both approaches

Service level management and liability

Both approaches generate added value by sharing existing technical platforms for different services. This has the effect that single service parts are provided by different involved actors which do not necessarily have a contractual relation. E.g. in order to take a correct decision whether the vehicle is located on a tolled road the tolling service depends on the quality of the GNSS-positions provided by

the smartphone or in-vehicle platform. The function of GNSS-positioning is not under control of the toll service provider. So questions concerning responsibility and liability for damages will arise, if payment transactions are produced incorrectly and toll revenue is missing due to poor quality of the provided GNSS-positions.

In order to assign responsibility clearly and create a transparent liability situation it will be necessary that both technical and qualitative compliance levels will be agreed, continuously measured and monitored. If those levels are not achieved the service has to report and signalize this to the user.7 E.g. in case of a tolling service which runs on a smartphone or in-vehicle platform the improper operational status should be signalized to the user who has to take respective actions (e.g. improve reception of GNSS-signals, use alternative method to pay tolls).

Designing and establishing business model

By enabling a shared usage of existing technical platforms for services instead of establishing and maintaining dedicated platforms the cost-efficiency can be increased. The party which provides the platform for other services will expect to get its effort remunerated.

If a user opens his smartphone or in-vehicle platform to be used for tolling and accepts the related obligations he will probably expect to participate somehow in the cost savings by the toll service provider. This could be e.g. reimbursements or discounts. When designing such benefit models the specific regulatory basis for tolling must be taken into account. E.g. whether the tolls are designated as a tax or fee might affect the possibilities of reimbursement and discounts.

When opening an existing tolling platform for a shared usage by other services a toll service provider can either provide additional services by himself to the end user or he can provide the base functionalities to other 3rd party providers who integrate them in their final service to the end customer. In the first case the business relation is clear and the (toll) service provider will get his effort remunerated by the end users. In the second case a solution for the remuneration of the usage of base functionalities between the toll service provider and the value-added service provider needs to be found and implemented (e.g. flat price per time period, pay per use, etc.).

4.2 Challenges when using existing infrastructures for tolling

Access must be non-discriminatory

Road user charges apply for every vehicle liable to pay toll that uses a tolled road. The toll charger has to ensure that everyone who wants to pay their toll will find a way to do so.

One of the benefits of the approach to use existing technical platforms (smartphones, in-vehicle platforms) for tolling is their wide penetration. Anyway the situation that participants have neither an in-vehicle platform nor a smartphone or do not want to use it for tolling has to be considered. In those

[7] Specific design principles which should be considered in cooperative systems from a liability point of view have been identified and described within Action 5.2 of the EC's ITS Action Plan. The final report can be found at: http://ec.europa.eu/transport/themes/its/studies/doc/2012-liability- aspects-of-its-final report.pdf

cases an alternative booking system or the provision of dedicated on-board equipment for tolling is still needed.

Solution for Enforcement/Compliance Checking

At the moment the enforcement and compliance checking is conducted in most cases by using Dedicated Short Range communication. Enforcement units (e.g. road side equipment, enforcement vehicles) communicate with the tolling equipment and the relevant data (e.g. operational status, declared toll relevant parameters, etc.) are transmitted in order to decide whether the road user complies with the regulations.

The functionality of Dedicated Short Range communication is currently not available or at least very uncommon in smartphones and in-vehicle platforms. In the field of in-vehicle platforms the development of Car-to-X applications will probably support the availability of DSRC functionality in the future. Nevertheless solutions have to be found on how compliance checking can be conducted if smartphones are used for tolling. DSRC-adapters could be developed which then could be connected to the smartphone as a first step. In longer term the enforcement systems could be adapted to use existing basic wireless communication technologies of smartphones like WLAN or RFID.

4.3 Challenges when using tolling infrastructures for other value added services

Limitations due to HMI of tolling equipment

The requirements of interaction of the tolling device with the road user are limited. If in the respective tolling scheme parameters which can possibly change with every journey (e.g. number of axles of the truck incl. trailer, actual total weight, etc.) are relevant for the amount of toll, the user needs to set the actual state of those parameters in the OBE prior to every journey. The OBE needs to show the current parameter configuration to the user. Furthermore the OBE needs to show its actual operational status which is in most cases very simple (OK / nOK). The OBE's possibilities of user interaction are limited and do definitely not meet the requirements of sophisticated telematics services with a high level of user interaction. The challenge is therefore to find suitable services for which the existing base functionalities provided by the tolling OBE are sufficient. Especially services which are primarily used by logistics dispatchers or fleet managers like tracking/tracing or remote vehicle diagnostics and not by the vehicle driver seem to be suitable.

Connection to vehicle information would help to enable broader range of services

A tolling OBE is in most cases technically not integrated into the vehicle electronic system except a connection to the power supply and sometimes to the speedometer. An additional link to vehicle information would enable a broader range of services. E.g. the CAN-bus of the most European heavy goods vehicles (Daimler, MAN, Scania, Volvo, Renault Trucks, DAF Trucks and IVECO) contains data according to the FMS-standard8 (fleet management system) which could be accessed and

[8] http://www.fms-standard.com/

transmitted. Through such an interface to the CAN-bus information like e.g. fuel level, fuel consumption and engine temperature can be evaluated and further processed in telematics services.

Cross-border functionality has to be ensured

The users of (professional) telematics services (e.g. tracking/tracing) expect that the service is not locally limited to a specific region or country. Ensuring cross-border functionality is a challenge in particular when thinking about services which shall use base functionalities of a tolling platform. Up to now tolling systems are operated mainly with a local or national focus. However some tolling systems in the field of heavy goods vehicles have already implemented cross-border compatibility in small scale, e.g. Germany with Austria or Austria with the Scandinavian countries.

The implementation of a harmonized pan-European electronic tolling service (EETS) for HGV is currently in the course of development by the member states of the European Union and supported by the European commission.9 For the convenience of the road users only one OBE and one contract with a service provider shall be sufficient to pay the road charges in all European toll domains.

The successful implementation of the EETS would thereby be an important support for the approach to enable a shared usage of tolling platforms by additional services as it provides the basis for cross-border functionality.

5. Summary and conclusion

Maintaining a proper road infrastructure is one important aspect to sustain our mobility. High investments will be needed in the future. Road user charging will be one important source of financing. Since the introduction or expansion of tolling schemes has at first glance always a negative connotation it is important to consider two aspects. The collected toll revenue shall be assigned to finance infrastructure only (and not overall budget holes). The system for toll collection and enforcement shall be cost-effective which means that the costs stay in a reasonable relation to the presumed toll revenue. The first point needs to be addressed when designing and establishing the political and regulatory framework. The second point can be achieved by connecting the tolling service with other services or with existing technical platforms intelligently. This creates synergies which can be used to reduce the toll-related costs and improves system's efficiency.

Especially with respect to the introduction of tolling schemes for passenger cars more efficient solutions needs to be found, that do not require installing dedicated technical equipment in each vehicle. Here existing technical platforms such as smartphones or in-vehicle platforms could be used which would lead to increased cost-effectiveness and user convenience. The implementation of enforcement processes and especially the transmission of enforcement data is one major challenge which still has to be solved. Furthermore it has to be considered that not every user will be able or willing to provide his individual platform for tolling purposes. Therefore alternative possibilities to

[9] See e.g. http://ec.europa.eu/transport/themes/its/road/application_areas/electronic_pricing_and_payment_en.htm

pay road charges still have to be provided.

With respect to already existing toll systems a shared usage of existing basic functionalities by other telematics services would support their efficiency. In GNSS toll systems, these are the existing GNSS-positioning and communication channels over cellular network and dedicated short range (DSRC). The limited possibilities of the HMI of tolling OBEs needs to be considered as it limits the range of possible application to those ones, which have low or do not require user interaction in the vehicle. Further challenges are the cross-border functionality because nowadays toll systems still focus on local or national context and lack a technical link between the tolling OBE and the vehicle to obtain vehicle data.

The main challenges in general arise from the concept of shared usage of technical resources which applies to both approaches. In particular solutions need to be found on how the parts of the service which are outside of the control of the service provider can be clearly defined and delimited. This is essential to clearly assign responsibility in case of problems or malfunctions and thus to clarify potential liability for damages. Furthermore, sustainable business models need to be developed for both approaches that create benefits for all involved stakeholders at reasonable costs and risks.