White paper:
Open Traffic Alliance

Next generation traffic content management systems

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Purpose

This whitepaper presents a vision on how public and private traffic content and systems will converge enabling new innovations for road users as well as added value for private parties and governmental bodies. The convergence of these systems will result in an open ecosystem with new possibilities in the emerging market of intelligent traffic management.

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Glossary

CMD	Cooperative Mobility Device
CMS	Content Management System
DITCM	Dutch Integrated Test site for Cooperative Mobility
ETL	Extract, Transform, Load
ITS	Intelligent Transportation Systems
NDS	Navigation Data Standard
OBU	On-board unit
OpenLR	Open Location Referencing
OSGi	Open Services Gateway initiative framework
PND	Personal Navigation Device
RSE	Roadside equipment
SDK	Software Development Kit
SPITS	Strategic Platform for Intelligent Traffic Systems
TM	Traffic Management
V2X	Vehicle-to-vehicle and vehicle-to-infrastructure (communication)

Abstract

Traffic management is on the verge of a paradigm shift. Currently, public road authorities measure network performance and utilize public signage to influence road users. This approach is suboptimal due to high costs and relative low effectiveness, as opposed to the solutions of private market parties that offer more and better data at lower cost, especially when using floating car data from vehicles that are connected to a back office.

A big opportunity lies therefore in combining traffic information of both public and private parties via a platform that supports the convergence of both data infrastructures. In this whitepaper, a platform is described that finds its origins in the 'Open Data Center Alliance[1]' initiative. Major ICT industry vendors, e.g. Intel, BMW and Shell, formed this alliance in 2010 with the mission to define requirements for the next generation data center and cloud infrastructure. These next generation data centers revolve around the notion of the convergence of data infrastructures and open cloud computing.
This platform forms one of the essential pillars within the approach that is called 'Deployment of a Strategic Platform for Intelligent Traffic Systems based on public-private ecosystems'.*
The other pillar is based upon the development of the Cooperative Mobility Device, the in-car platform for Intelligent Transportation Systems and mobility services. This however, is out of scope for this document.

* the white paper covering this topic is still in the editing phase

[1] http://www.opendatacenteralliance.org/

Introduction

An increasing number of cars have an on-board connected navigation system with the ability to upload traffic information to a central server. On the server, the information is aggregated from all connected cars and enriched with information from other sources. After statistical analysis and validation, the information is fed back to the entire fleet of connected cars as live traffic data.

The primary use case for this data is to avoid traffic jams. The devices and the data are part of closed information systems from their respective navigation services suppliers.
Next to the navigation services suppliers, public road authorities also accumulate live traffic data using public road infrastructure systems such as road cameras and detection loops.

There is a big potential for new businesses and services if private navigation information systems and public infrastructure systems would converge into an ecosystem, for example:

- Integration of the road signage information in the user interface of the in-car navigation system;
- Over-the-air dynamic content provisioning services, like just-in-time map updates or location based dynamic content;
- A historic database of live traffic data that is used for structural planning of road infrastructure;
- Location based services, such as the routing to a free parking place or charging station;
- Incident management services, for instance re-routing traffic in case of an accident or temporary road construction;
- Traffic management, in the form of load balancing traffic based on public information that is broadcasted by traffic control centers;
- Driver guidance, for instance by giving speed advice to achieve a better traffic flow;
- Pre-crash warnings: warn a truck driver that he is approaching a tunnel with a height clearance that is too low;
- Pay-as-you-drive services, for instance a toll application or rewarding drivers for good driving behavior.

This white paper discusses the needs and technologies driving the paradigm shift of private connected navigation systems and public road infrastructure systems into a larger, open ecosystem for future traffic management.

It also explains the rationale behind using open-source software and governance through public-private communities.

Proposal

There is great opportunity for the Netherlands in the emerging worldwide market of traffic information services by founding a Dutch public-private community and gaining a leading position by having such an integrated traffic information ecosystem operational. Also, a wide range of other mobility services will benefit from the proposed integration.

Not only will this lead to new business initiatives, but also will this affirm the Netherlands' worldwide high ranking in innovation and knowledge, thereby ensuring its strong economic position.

Blueprint of a public-private traffic management system

Current situation

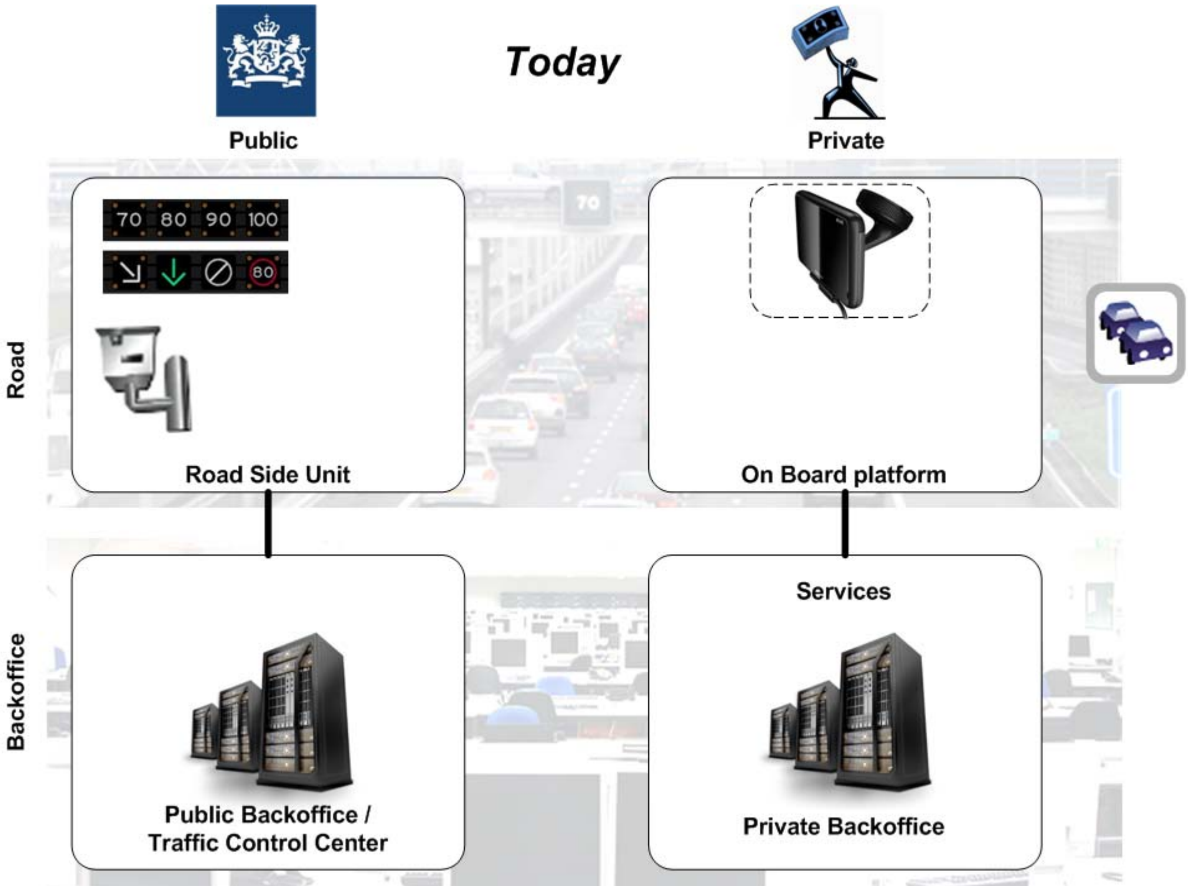

Figure 1: Current traffic management situation

On the left, the public infrastructure system is shown. This system is connected to a central traffic management system exploited by government. It connects to the road-infrastructure systems and to other systems managing public content (e.g. parking facility exploited by local governments).
On the right, today's private navigation services system is shown for private navigation devices in the car. Similar systems can be identified within markets such as fleet management and usage based insurance.

Proposed situation

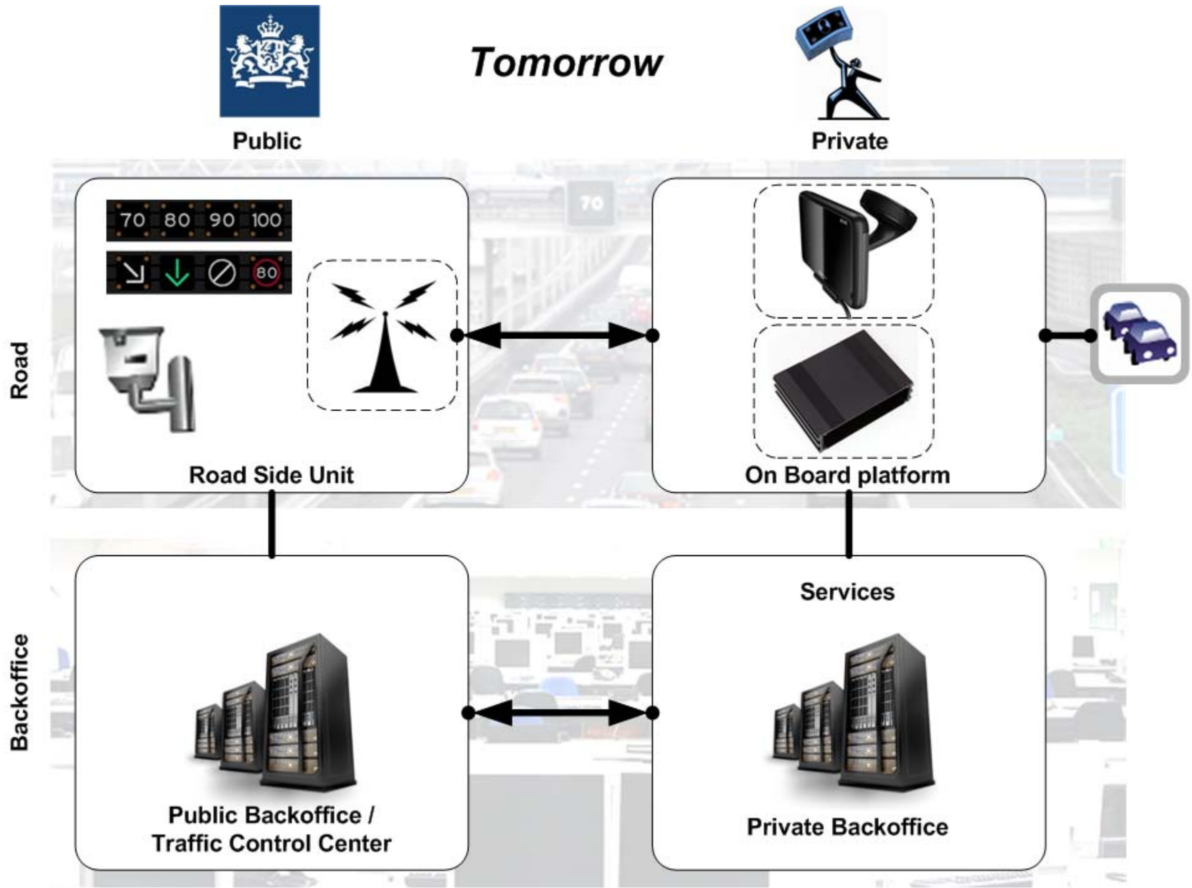

Figure 2: Proposed traffic management situation

In the converged system, the navigation services system provides live traffic information obtained from the 'connected navigation' fleets to the public infrastructure system. The public infrastructure system provides live traffic information obtained from the public infrastructures to navigation and other ecosystems. This exchange of information is enabled by a gateway between the public and private systems. This gateway supports the convergence of different data infrastructures as well as isolation between different incremental changes between the different private and public systems. Thus preventing the disturbance of the internal processes of Traffic Control Centers.

Apart from the aforementioned convergence between data infrastructures and systems, there is also an increasing need for information exchange between predominantly public roadside units and private vehicles.
Enabling information exchange between the public infrastructure systems and private vehicles has the following advantages:

- Enabling the creation of new driver assistance services through the availability of live public data;
- Enabling the creation of new traffic information- and management services based on the interoperability of the road infrastructure systems and the navigation systems;
- Enabling the creation of more accurate content by combining the information obtained from both the road infrastructure and the cars.

Essential aspects

Content mining from car and its environment

One of the key aspects of generating live traffic data is the content mining from cars and their local environments. At present, the content mining capabilities of in-car systems are limited and the process of combining, validation and processing of traffic feeds still involves a lot of handwork.

With the advent of pending innovations for data capturing and enrichment from the car and the use of ETL systems for automatic data processing and traffic feed creation, the transition of static to dynamic traffic content systems is possible.

However, the quality of service is directly linked to the quality of the content, so to maintain a minimum quality, a self-regulating system needs to be set up that not only performs automatic traffic content feed generation, but also incorporates a reputation model for content providers, taking preference of high ranking data suppliers.

Incremental content updates

Many next generation traffic information applications require an up-to-date map. It is therefore essential that just-in-time map updates can occur using a real time OTA map provisioning system. Typical map data sizes are in the range of 2 to 8 GB, which is too big to update over the air, especially when taking into account today's bandwidth constraints, download limits and roaming costs.

Today the following classes of navigation systems exist:

- Systems with an on-board map. The quality of service is in this case independent of the connectivity;
- Systems with an off-board map, so called off-board systems. The quality of service is in this case tightly coupled to the on-line connection between the car and the cloud.

So called hybrid-navigation systems are emerging that offer a better experience providing the quality of service of on-board systems while keeping in sync with fresh content in the cloud.

Essential for such a hybrid navigation system is:

- The ability to make best use of the local connectivity possibilities to scale cost-of-connectivity versus freshness of the data;
- A provisioning system for incremental content updates;
- A device management system that is able to produce increments for the on-board map system.

Indirectly, the connectivity trends for connected cars, such as the use of WiFi-p, digital broadcasting or cellular networks will influence the system policies applied for hybrid navigation systems. To achieve a robust and efficient system for distribution of content, the provisioning system should embed a network management layer making best use of the available connectivity.

Cooperative Mobility Device

Current navigation systems are designed for turn-by-turn navigation and not for next generation traffic information services. Based on more adaptive traffic management concepts, a new product concept needs to be introduced. This concept is an evolution of today's PND's that is enhanced with technology that enables smart mobility use cases, such as:

- Better adaptation to in-car usage;
- Inter-operability with in-car networks;
- Inter-operability with in-car telematics units;
- Support for V2X communication;
- Extended content mining capabilities, e.g. mining content from vision systems;
- Interoperability with incremental software- and content provisioning systems;
- Open for third party applications;
- Navigation technology adapted for cooperative systems.

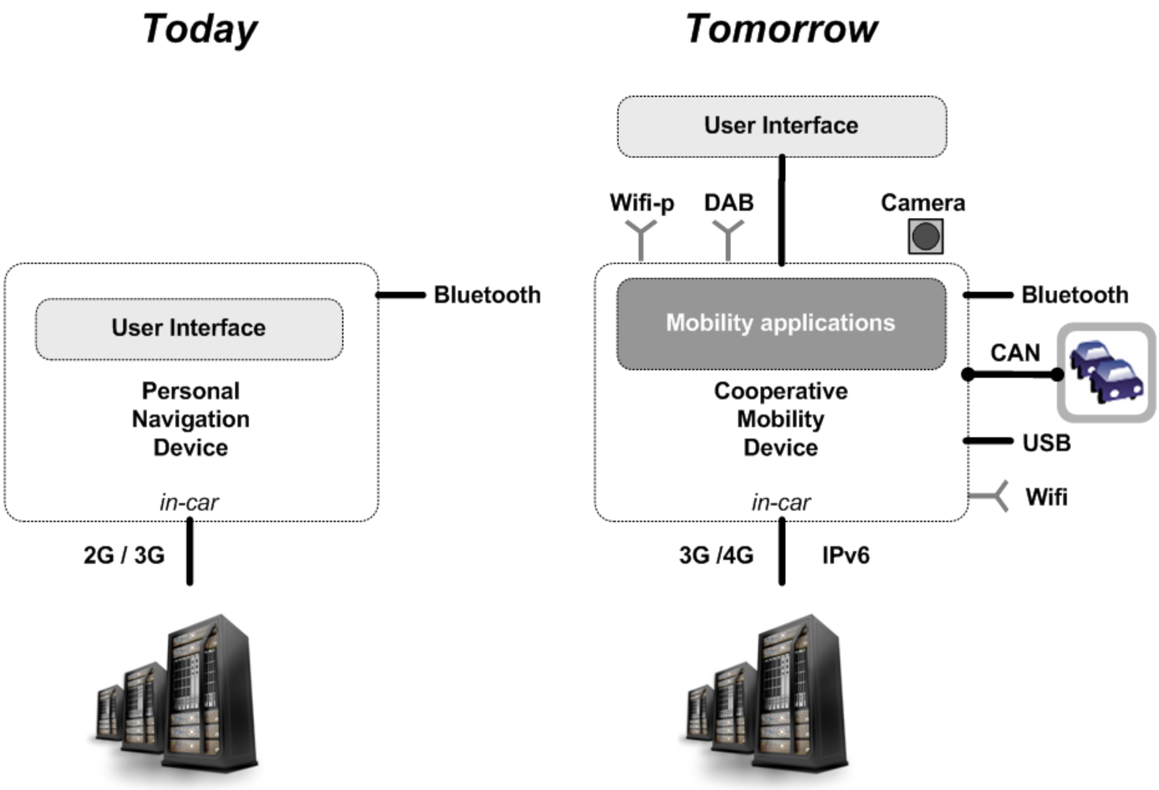

Figure 3: Comparison of the PND and the CMD

Specialized app markets

One of the key aspects of the aforementioned CMD is that it is open for third party applications. For this, it is expected that specialized 'app markets' will evolve for ITS applications, much like the off-the-shelf smart phone app markets, but validated against in-car usage regulations.

Open innovation and Open Source implementations

The anticipated convergence and proposed platform are, in themselves, answers to a growing need for new traffic management solutions. One of the inherent aspects associated with these new solutions is that they find their origin in an open information ecosystem. This ecosystem can only emerge if parties join in an open pre-competitive innovation effort. A proven pattern to accelerate and secure this innovation is to create Open Source reference implementation that not only features a reference architecture but also the most important open data interfaces.

In order to successfully develop such an ecosystem, a number of criteria must be met:

- First and foremost all involved parties need to share an identical vision and must be prepared to share this vision in concrete, pre-competitive implementations.
- Secondly, a transparent and neutral governance structure needs to be present that is aimed at implementing a roadmap-based development strategy. For an example

of well-proven governance structures, one can refer to the Apache[2] foundation or the JCP[3].

- Finally, a process needs to be implemented that ensures that Open Source implementations are frequently taken to the market or prototypes. Fundamentally, this process should be aimed at preventing the creation of glass houses.

Ultimately, this will result in a common deployment platform that offers the right adaptability and scalability to host the services from different service suppliers. Although the framework will be developed in a pre-competitive setting using open interfaces it still allows the use of proprietary technological components from specialized vendors when this is beneficial for the overall system.

Proposed architecture

The essential aspects outlined above are all from a rather disparate background, so it is important to outline an overall conceptual architecture that balances these different backgrounds in one overall design.
In order to appreciate the architecture that is 'fit-for-purpose' for the adaptive traffic domain, we need to step back from the deployment-oriented illustrations used earlier in the document in figures 1 and 2. The conceptual architecture hat best fits the requirements and the anticipated changes in the traffic management domain, is based on the approach that a cooperative, data-driven ecosystem needs to emerge that promotes the systems described earlier to publishers and subscribers at the same time in a defines data-processing domain.

The conceptual architecture is outlined in the next illustration.

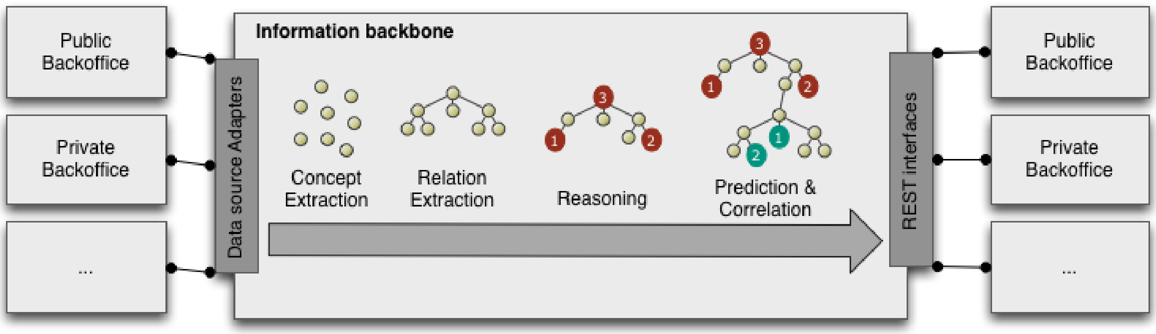

Figure 4: Conceptual architecture for collaborative traffic management systems.

This conceptual architecture is designed around the following fundamental capabilities:

1. **Evolvability**
   In the first place, the architecture should enable the evolution of (parts of) systems in terms of behavior and data. For the first type of evolution, any system in this

[2] http://www.apache.org/foundation/how-it-works.html
[3] http://jcp.org/en/procedures/jcp2

architecture should be based on modular services designs. This enables the structural and controlled adaption of functionality of (parts of) a system. Based on this evolvability, it is possible to evolve interface structures and data signatures as well.

2. **High-volume data processing**
   Another complexity that needs to be resolved is the capability to handle large data volumes while still processing this data in terms of addressing, representation as well data-contents. The transformations and routing that implement these capabilities are contained in the "Information Backbone" component of this architecture.
3. **Collaborative and adaptive coordination**
   An important difference between the traffic management systems mentioned in this white paper and the existing systems finds its origin in the fact that new unforeseen ways of interconnecting and integration will be typical. It is therefore required that the architecture supports a flexible (i.e. service-based) approach to coordination and integration patterns between connected systems.
4. **Open integration**
   Finally, the architecture needs to be integration oriented without claiming one specific approach to be the best. In order to achieve that, this architecture assumes that every connected system can be updated and adapted to meet the best fitting solution.

Trends

Technology trends

NDS, a standard map format

Today's navigation systems use non-scalable, proprietary digital map formats that are not interchangeable. This severely hampers the introduction of value networks exploiting the next generation traffic information systems. Not only is it impossible for independent map data suppliers to provision new content, but also the lack of scalability prevents the use of incremental map updates in an open navigation system.
To overcome these problems, the NDS format is developed by automotive consortia over the last several years with the ambition to break through the barrier of vendor lock-in by the current map suppliers. NDS provides map data in a scalable, open format that is well suited for OTA incremental map updates.

OpenLR

To relate dynamic content to the on-board map, a location referencing system is needed to transform the location information and related attributes between different map instantiations, for example to relate an incident on a specific location to road segments within the navigation system's digital map. OpenLR is an open-source solution that supports the right level of quality.

OSGi

To build traffic management systems that feature a mature level of evolvability and robustness, it is mandatory to apply a modularity-based development strategy[4]. Succesfully applying this development strategy makes it possible to add and remove software modules from a system at run-time and allowing the addition and upgrading of functional blocks within the system without impacting the uptime of running production services. The most mature standard in the field of software modularity is OSGi[5]; a standard that was started in the early 2000's.
In general the OSGI standard is implemented using a standard compliant framework. Currently most Java-based server platforms with a significant level of adoption feature OSGi support and a good number of well-known software titles implementing this framework and are backed by an open alliance.

Computer Vision technologies

Another emerging trend in traffic content mining is the use of computer vision technologies, such as lane detection, traffic sign interpretation and collision warning. The camera used in these technologies might also be employed for real time driving assistance using augmented reality techniques.

The Amdatu cloud data platform

For the SPITS project, several mobility services were developed on a proprietary TomTom platform. To be able to make a transition to an open collaborative effort, these traffic management services may need to be ported to an open, cloud-based platform.
Amdatu, a Dutch initiative, is an OSGi based, open cloud data platform and is a good match for hosting public-private ITS services. The existing SPITS services can be ported to Amdatu with relative ease and new services can be developed using the modular approach that is enforced by the OSGi architecture.

Other trends

Open data

There are strong developments in the public domain that stimulate or even enforce the accessibility of public data. For example, in the Netherlands there are quite some data repositories that are publicly available as open formats via public websites. Although legal and operational issues for open data in the traffic domain still remain to be solved, it is expected that the proposed initiative fits in this policy trend very well.

Reputation system

To be able to attain a certain level of service data quality, the incoming data needs to be validated.

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[4] Modularity finds its roots in Dijkstra's argument on "separation of concerns" dating back to the early 70's (http://amturing.acm.org/award_winners/dijkstra_1053701.cfm).
[5] See also http://www.osgi.org

For example, users or road authorities may report a traffic incident. The incoming data may be validated against traffic flow that is measured at the applicable road segment. After validation of this traffic incident occurrence, the traffic data can be dispatched to connected navigation systems. To increase the efficiency of the validation process, a reputation system will be applied to help filter out unreliable sources and ghost reports.

Governance

The development of a public-private data-sharing platform will be a joint effort amongst the participating members. To organize such development in the European context, an independent organ such as Ertico could be employed to perform the governance of a platform that is financed through government funding.

Open source platform model

A basic requirement for the content management software is to be able to run on the various server configurations owned by the different legal entities. Next to this, each participating partner will want to tailor the system to their specific business needs or integrate it with existing systems. For this to be possible, the partners need to have access to the source code.
To have the platform available as open source software means that there is no dependency on a third party for implementation and integration, thus changes can be propagated across the different partners more quickly. Next to this, the platform is intended to host traffic data services distributed over public and private systems that interoperate through open data interfaces.

Quality of Service

Traffic services should not negatively impact the safety of road users or the environment, and therefore it is a responsibility of the government to guarantee a minimum level of quality regarding traffic service data. To achieve this, the use of open data models and standard interfaces between the back office and the various content providers should be a precondition.
In this way, the content can be monitored and validated via automated processes, ensuring a constant quality of service. The open system also enables the creation of policies that may be enforced to regulate the quality.

Roles of the stakeholders

Short term: investment in kick start of platform development

To start the development of the shared platform, the forming of a consortium will have to take place. There are two reasons why this will not happen without a strategic financial injection:

1. ICT suppliers and road operators gain their value by locking in governments to their proprietary back office systems. To break through this closed value chain and have

them publish their content online will need explicit enforcement and/or financial compensation.
2. Navigation system suppliers and other service providers will have to make high investments to reorganize their back office systems. At the same time, individual customers will show little interest in an emerging market that does not offer appealing use cases for the public yet. It will need several trials to see how the public-private benefits can be monetized.

To gain momentum in the platform development, it is paramount to create a partnership of market leading companies that fit in. This is necessary to ensure that the time to market of the newly developed traffic services is short enough for system suppliers to adopt them in their ITS business.

For a successful open-source development partnership, it is very important to be critical in selecting partners. Partners may want to join for various reasons:

- Accelerating their roadmap using external funding
- Funding their cost-of-sale activities
- Building up business intelligence
- Building up an intimate relationship with government or business partners
- Create a vendor lock-in to their proprietary solutions

To be successful and to become a competitive world-leading player, it is important that the primary reason for participation is the sincere intention to create a value network accelerating the emerging market.

The current tendering model doesn't cater for the natural selection of IT partners with the above ambition. In the contrary, there is a customer intimacy relation built in the past between governmental parties and traditional IT suppliers tendering for traffic infrastructures. In many cases, those suppliers also provide the consultancy service to define the architecture for the future IT systems.
There will be a natural tendency of those parties to lockout new entrants.

Medium term: investment in field trials and the Cooperative Mobility Device

Before the newly developed traffic services can be rolled out commercially for the public, initial research and trial experiments need to be performed. The system needs to undergo exhaustive testing with a significant amount of vehicles in a controlled environment before it reaches a production ready state. The obvious starting point for such a controlled environment is the DITCM facilities and network.

For this, a device is needed that is designed specifically for this purpose with a cost acceptable to run large-scale trials. A similar device, albeit in prototype status, was developed for the SPITS project, but with a modular setup to experiment with different hardware configurations. This device setup is too expensive to use in large-scale trials though.

For the public-private data platform a new type of device is needed with lower cost by using the latest smart phone technologies that went through a huge price erosion the last years and by dropping several modularity options. This new device will be able to interoperate with smart phones, PND's or head-units and will be in the EUR 250-400 price range. This device could serve as a step-up for the development of a commercial grade ITS box that is part of the future 'connected car'.

A possible scenario is one where the government buys a 'medium' volume of such ITS boxes and endorses the use of this box in nationwide trials.

Long term: investment in production situation

In the long term, a balance is expected to emerge between the costs and the benefits of the proposed collaboration for each stakeholder. The benefits of sharing public-private traffic data are expected to be distributed between the individual driver, private enterprises, public road owners, local communities and society as a whole.
This implies that also the costs will be shared, although it is virtually impossible to apply a strict cost allocation method for this. The best feasible business models still have to be prototyped and evaluated in parallel with the trials as mentioned above.

It is expected that drivers will pay for a large part of the in-vehicle hardware cost (with potential tax incentives from government or enterprises/lease companies/insurance companies), whereas the public sector will invest in roadside systems, data-gathering infrastructure and other entities with shared usage. One can also envisage a deduction in communication costs financed by the government as a compensation for the increased value of the aggregated data. Service providers will probably invest in new services and recapture their investments in service or communication fees.

Stepwise deployment

There are several steps to taken into account to deploy the platform in the EU and ultimately around the world. After a short proof of concept phase a large scale Field Operational Test is proposed to pave the way for nation-wide deployment in the Netherlands; meanwhile negotiations with other EU member states can be started to transfer the collaborative effort to other countries.

The "Beter Benutten" program

A Dutch partnership should be initiated to build the platform for ITS and roll it out in initiatives like "Beter Benutten" and "Praktijkproef Amsterdam". These activities are expected to be started early 2013.

Participation in EU subsidy programs

Also for 2013 and beyond a number of trials are planned in the EU subsidy programs. However, the platform development in all those initiatives is fragmented. A more efficient

approach would be to organize a platform development that is shared between all the subsidy programs.
If an independent organ such as Ertico organizes the governance of the platform development, the shared platform development could benefit most of the available subsidy programs. A coordinated effort to achieve such a platform should be initiated on a short term and could be consolidated within the DITCM initiative as mentioned earlier.

Participation in US-DOT programs

In the USA US-DOT programs are tendered in the context of WiFi-p and cooperative mobility. There is an opportunity to participate in those tender programs to investigate the cooperative mobility market potential in the USA.

Promotional activities

To create adoption of the platform, promotional activities will be needed to create visibility of the platform and its capabilities. For this promotion existing networks can be used such as Connekt, AutomotiveNL, DITCM in the Netherlands and ERTRAC and EasyWay in the EU.

Outlook

With the start of Dutch initiatives like “Beter Benutten”, the next 2-4 years could be crucial in developing, prototyping and deploying an open traffic alliance approach towards public-private use of rich, real time traffic-related data. This will be a crucial element in achieving the new approach toward car-centric traffic management and new mobility services that improve safety, reduce emissions and shorten travel times for the whole of society.

Through the issuing of this paper the involved stakeholders and partners are challenged to collaborate and to take bold steps to bring this vision closer to reality.