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A proposal of ingesting dynamic speed limits for traffic management

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Abstract

Talking about road safety, one of the major limitations for Traffic Management Centres when publishing events to driver applications, is the speed reduction that they should apply in the presence of those traffic incidences. The intensity or strength, and the environment conditions where these incidences arise, play a critical role for the percentage of speed reduction that should be applied. In general, speed limits, drivers behaviour and traffic conditions, vary greatly among cities. Defining consistent rules based on the particular conditions of cities, is key for Traffic Management Centres in order to provide reasonable speed recommendation to drivers, that can increase road safety. In accordance with what has been analyzed in this publication, the most important conclusion drawn by this study is that it is possible to provide to the city Traffic Management Centres dynamic speed limits information based on real-time incidents.

Keywords:
Traffic management, Safety roads

Introduction

Considerable advances have been made in designing and implementing traffic control and regulation preparing the proper transition to the new and demanding agenda of European small and medium-sized cities regarding speed adaptation and ultimately decarbonization (Fuso Nerini F, 2019).

Advanced forms of traffic signalling are often self-optimizing and self-organizing catering for different scenarios in large urban and metropolitan areas where there is a need to control traffic and give priority to public transport (Roozemond, 1998). From a safety perspective, improving signal timing can reduce speed dispersion, reduce the occurrence of rear-end collisions, prevent accidents resulting through red-light violations, and provide added protection to pedestrians and cyclists (Taylor, 1997).
As a component of Active Traffic Management (ATM), Dynamic Speed Limit (DSL) systems aims to improve traffic safety through reductions in mean speeds and in speed variations within and across lanes, and between upstream and downstream flows. Apart from affecting traffic safety, DSLs could also have effects on smoother traffic flow, congestion, and travel times, as well as on vehicle emissions and road noise. Variable Speed Limits (VSL) are often used as a synonym for DSLs (Daniels, 2017). DSL or VSL uses infrastructure-based technologies such as Variable Message Signs (VMS) that are often used to inform drivers of crashes, adverse road conditions such as congestion, road works, weather conditions, or other factors requiring an increase in awareness and a reduction in speed. These signs are often automated or semi-automated in conjunction with a traffic management and control strategy and can provide timely information as and when it is needed (Transportation Research Board, 1998).

Requirements to ingest (calculus and distribution) dynamic speed limits.

As presented in (Dacasa, Iñaki et al. 2022) the major goal of CELESTE Project as a DSL Compliance Solution is to publish dynamic speed limits and make them usable for cities and municipalities, as well as developers and end users. The project investigated the requirements to ingest (calculus and distribution) of dynamic speed limits in the whole traffic management value chain: data platforms, national access points, vehicles, and VMS. Figure 1 shows a diagram of System Architecture.

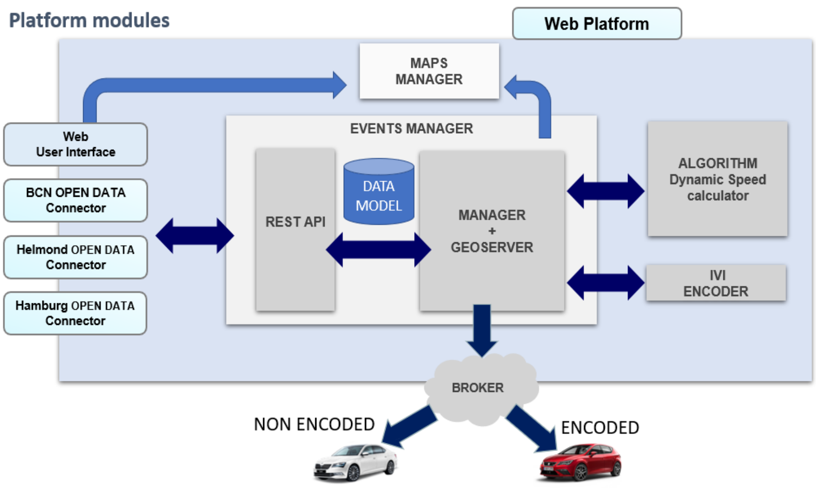

Figure 1. System Architecture.

Requirements for data platforms

The Hamburg Urban Platform (UDP_HH) facilitate data from various authorities and institutions of the city and made it available non-discriminatorily to the public for various applications in an interoperable manner via standardized interfaces. For example, geodata can be displayed in the web-based map application Geoportal Hamburg. The UDP_HH is a modular platform that follows the general reference architecture of the European Innovation Partnership on Smart Cities and Communities on Urban Data

Platforms as well as the DIN specification 91357 Open Urban Platform.

Starting from existing systems in which data are available, the UDP_HH takes data into an information data store via interfaces and various formats and makes them available to other internal and external systems via a standardized service layer. The UDP_HH relies on standards of the Open Geospatial Consortium, which in many cases have also been further qualified to standards of the International Standards Organization. (Free and hanseatic city of Hamburg (b), 2022).

The following requirements exist for the successful integration of the CELESTE data to the UDP_HH and thus the provision of dynamic speed limits on an urban platform:

- The data set needs to be complete; quality assured and meet the high-quality requirements; a test data set cannot be published due to quality aspects,
- a metadata description must be given,
- an application form and a declaration of clearance must be submitted,
- the visualization of the data or information on the web interface of the UDP_HH must be defined.

The Dutch governments work together to collect, combine, store and distribute mobility data to the National Data Warehouse Portal (NDW). As a city, also Helmond is obliged to provide data to NDW who then translates it into, for example, the speed limits map Nationale Databank Wegverkeersgegevens (NWB) and the roadworks map MELden van Verstoringen in de Infrastructuur in Nederland (Melvin). Melvin is the reporting system for road authorities to report road works and events. Reports in Melvin are visible on the public website when published by the road authority. When road operators in Helmond coordinate road works, these are applied into Melvin, and through Melvin the road works data is sent to CELESTE.

There are three different sources for events we considered for the use case in the area of the city of Helmond:

1) Melvin: “Roadworks” and “Event area” events,
2) Buienradar: “Heavy rain”, “Strong wind” and “Fog” events,
3) Manual data: “Bicycle presence”.

The interface between Melvin and CELESTE is the Helmond connector. This is a Django application that reads the sources periodically (Melvin datasets included) through Melvin’s API, formats the data and creates the resultant events to be published in CELESTE. This publication is made through the CELESTE’s API.
Buienradar does not have information about Helmond, so measures had to be taken from the closest city available. This could have been solved by getting this data from another source if another source exists.

Requirements for vehicles
IVI service (N.Asselin-Miller et al., 2016) is one instantiation of the infrastructure services to manage

the generation, transmission and reception of the In Vehicle Information Messages. In Vehicle Information Message (IVIM) is originally standardized in CEN ISO/TS 1932 (ISO, 2015). In addition to the message the ETSI standard (ETIS, 2018) also defines a facility layer protocol and requirements. IVIMs are used to communicate the content of static and dynamic road signs, such as (temporary) speed limits and road works warnings (SAE International, 2020). An IVIM supports mandatory and advisory road signage such as contextual speeds and roadworks warnings. IVIM either provides information of physical road signs such as static or variable road signs, virtual signs or roadworks.
The aim of In-Vehicle-Signage (IVS) is to relay the information presented on (electronic) traffic signs into the vehicle. To that end, variable or dynamic message sign (VMS) systems have been deployed on sensitive parts of the motorway network all over Europe. They are being used in conjunction with monitoring systems to enforce traffic regulations (such as speed control and lane management) and inform road users about driving conditions, travel times, hazardous events and possible alternative routes. This use case foresees transmission of information on the current valid speed limit continuously, as set by the road operator because of e.g., road works, incidents, traffic jams.

In the project CELESTE, the car receives an IVIM message for IVS-DSLI (Dynamic Speed Limit Information use case) based on C-ROADS profile:

- ISO14823 DF is set with the next values:
    - pictogramCode→ serviceCategoryCode = regulatory
    - pictogramCode→ pictogramCategoryCode→ nature = 5
    - pictogramCode→ pictogramCategoryCode → serialNumber = 57
    - attributes→ spe→ speed limit unit = km/h
- Extra text is added to define the cause of the event.

Figure 2 shows an IVIM message example:

IVIM encoded (ASN1)	020600000001BA140004018089F1A49F6F227C6927DB489F45301000201398672A1B1B1E053FFFFFF8476EE87C23002AC008FF753FFCEF968C00D4EE2740E98D957C21FAEC784102C3042E000505B0C01FD05B0C01FD0427C024C20580200800103028E4243C110A05A9B1B437B7B61020B932B080

IVIM object (decoded)	value IVIM ::= {
	header { *protocolVersion* 2, *messageID* ivim, *stationID* 1 },
	ivi {
	mandatory {
	serviceProviderId { *countryCode* '10000101 00'B, *providerIdentifier* 1 }, iviIdentificationNumber 97, timeStamp 592464617327, validFrom 592464617325, validTo 592509600000, iviStatus new },
	optional {
	glc : {
	referencePosition { latitude 415019944, longitude 19047956, positionConfidenceEllipse { *semiMajorConfidence* unavailable, *semiMinorConfidence* unavailable, *semiMajorOrientation* unavailable },
	altitude { *altitudeValue* unavailable, *altitudeConfidence* unavailable } },
	parts {
	{ zoneId 1, zoneHeading 171, zone segment : { line deltaPositions : { { *deltaLatitude* -277, *deltaLongitude* -24 }, { deltaLatitude -3374, deltaLongitude 107 } } } },
	{ zoneId 2, zoneHeading 184, zone segment : { line deltaPositions : { { deltaLatitude 2914, deltaLongitude 255 }, { deltaLatitude 2914, deltaLongitude 255 } } } } } },
	giv : { {
	detectionZoneIds { 2 }, relevanceZoneIds { 1 }, direction sameDirection, iviType regulatoryMessages,
	roadSignCodes { {
	code iso14823 : {
	pictogramCode { serviceCategoryCode trafficSignPictogram : regulatory, pictogramCategoryCode { nature 5, serialNumber 57 } },
	attributes { spe : { speedLimitMax 30, unit kmperh } } } }
	},
	extraText { { layoutComponentId 1, language '10000101 00'B, textContent "School Area" } } } }
	}
	}
	}

Figure 2. IVIM Message example.

Requirements for VMS

Vehicle drivers whose vehicles are not equipped with an On-Board display or those who do not want to use an app or their cell phone in the vehicle can receive dynamic speed recommendations via roadside signs. Thus, the information regarding the speed limits as well as the speed limits themselves would be made accessible to all road users.

For the VMS, the use of a REST API interface was intended. With that it should be possible to establish a connection to the server of the CELESTE module so that the publication of the speed recommendations can take place automatically. Alternatively, manual control of the traffic sign could have been tested. Thus, an employee would take the role of the traffic control centre and adjust the speed limits manually based on the recommendations of the module.

Should there be a future requirement to publish dynamic speed limits as legally binding, then the implementation of a traffic sign is essential so that all road users (also those without an On-Board display or mobile phone in the car) receive the same information regarding speed limits.

A requirement for the use of the VMS is a stable internet connection, as well as the technical requirement to be able to communicate with the CELESTE server. In the future, security requirements, e.g., a secure mobile radio connection, would also have to be considered.

Conclusions

It was demonstrated the feasibility of ingesting (calculus and distribution) of dynamic speed limits messages on a city data platform considering the necessary preparation time and quality standards. The publication of dynamic speed limits via a VMS and the corresponding requirements, for example financial resources and coordination with authorities, were also investigated as part of the project.

To best take profit of the CELESTE project, thinking from a user perspective, three different "macro" actions would be recommended:

1. Deploy VMS as part of the traffic infrastructure:
    - External Panels would give redundant information to drivers already using CELESTE,
    - They would catch the attention of drivers not using CELESTE,
    - The whole traffic would gain dynamic information about why the traffic is being slowed down, which would contribute to a better reception from the drivers and other road users.
2. Making CELESTE available as a mobile app that can be mirrored into the car's infotainment center. This would integrate the CELESTE Information directly in the infotainment's display, thus improving the user experience.
3. Making CELESTE available as an in-car app that can access internal car's information bus. This would give the CELESTE function a whole complete user experience level, as in-car apps can access car's information and an automatic reduction of the car's speed could be thus developed.

Diving deeper into the technical CELESTE solution, we also have the following "micro" recommendations:

1. The informative pop-up message should be displayed a good distance before the beginning of the event. This results in the user being aware he or she will experience a speed reduction (if CELESTE acting directly on the vehicle's speed) – or he or she will be urged to reduce the speed (if CELESTE being only informative).
    - A distance of 100-200 m in streets with regulated speeds of 30-50 km/h is advised,
    - Tests were performed with signaling distances of approx. 500 m which were perceived as

too far away from the event.

2. The signaling (pop-up message) duration has also to be considered, as the user should be given enough time to be not only warned about the new valid speed but of the event's reason – remember the user's empathy towards the reason of the speed's reduction is a key factor for his or her acceptance of the system. We have tested with signaling duration across the distance mentioned in the previous point, until the beginning of the event, and it was positively perceived.
3. In the case of CELESTE having a direct influence on the vehicle's speed (as part of an automatized ADAS) the position in the street where the Traffic Management Center signals the event must be considered, as (following the recommendations before) should be signaled in the car 100-200 m before the event also to prepare a smooth deceleration.
   - In the case of a signaling position at the beginning of the street, the system does not have the time to prepare the deceleration smoothly.
   - Thus, our recommendation is to always signal at least 100 m after the beginning of the street.
4. The last variable to be considered is the street's mean traffic speed. We have experienced uncomfortable situations when reducing the vehicle's speed too much under it:
   - In urban streets with more than two lanes it seems like 30km/h is too slow and the other users have shown their discontent.
   - Displaying a CELESTE event in very long streets has produced a similar experience.
   - It must be considered that CELESTE will be available to only part of the users, so that a fluid convivence of both should be assured.
   - Our recommendation here is the Traffic Management Center should not be too restrictive in terms of minimum speed. It should take the street's mean traffic speed into account.

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