Geofencing to accelerate digital transitions in cities: Experiences and findings from the GeoSence project

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Abstract. Geofencing is a new tool that offers innovative solutions to manage and control traffic, transport, and mobility. The technology enables cities to define digital zones and to create dynamic rules for mobility within these zones. Here we report on three geofencing use cases, their results and lessons learned that were conducted as part of the joint European project GeoSence. In the city of Gothenburg, the performance of a geofencing-based retro-fitted intelligent speed assistance system was tested and evaluated in 20 vehicles of publicly procured transport services to support drivers in complying with new speed regulations around schools. In Munich, geofencing was used to implement and enforce a new station-based parking regulation for shared e-scooters in the city's old town. Thirdly, in Stockholm preconditions, processes and workflow for continuous changes and updating of the underlying digital geo-data bases were analysed to better understand institutional and practical challenges to implement geofencing-based digital transitions in future. Findings from the use cases and project accompanying surveys are evaluated regarding the general topics of transport management, including issues of data sharing and management, stakeholder involvement, technical & vehicle readiness, feasibility of technical platforms, as well as institutional problems related to governance, policies, resources and the acquiring of necessary competencies. We will finish with project lessons emphasizing aspects to accelerate digital transitions.

Keywords: Geofencing, ISA, micro-mobility

1 Introduction

1.1 Geofencing as a Tool for Digital Transition in Traffic

Societies are faced with many challenges that will require collaboration and innovative solutions to be solved. One of the challenges facing cities is the management - and planning of traffic, balancing between increased accessibility and availability for users while dealing with issues such as congestion, traffic accidents & incidents, and health and environmental issues. Investing in new physical infrastructure is needed but is usually very expensive and cities need to find more cost-effective ways to plan and manage traffic. New digital and connected solutions are being developed with the potential to effectively reduce these issues.

One of these solutions is geofencing. This project defines geofencing in traffic management and planning as the: "*Creation of a geofence for monitoring, informing, and controlling traffic (mobile objects/vehicles) located within, entering or exiting the geofence, using electronic communication technologies or pre-defined geofences embedded into the mobile objects/vehicles, where a geofence is defined as a virtual geographically located boundary, statically or dynamically defined*." [1].

Geofencing can be seen as merely a creation of virtual zones in which vehicles can restrict their speed or change to electric propulsion. This is only one part of the truth. In reality, geofencing-based services could become powerful tools enabling continuous digital communication between e.g., cities, mobility/transport operators and citizens, leading to more efficient, safe and less polluting traffic solutions.

1.2 About GeoSence

GeoSence is a JPI Urban Europe project, funded by Horizon 2020, with the objective to design, trial and evaluate new geofencing concepts and solutions for specific cases in cities and to propose new ways to deploy different geofencing applications. The project started in April 2021 and will finish in 2024 engaging with partners representing research institutes, universities, and local and national public authorities from four European countries. Three cities: Stockholm, Munich and Gothenburg are involved in the project, with their own use cases focusing mainly but not exclusively on the following:

(1) Stockholm is overviewing their role as a data provider and aims to improve their governance structure to better make use of georeferenced data such as traffic regulation data. This is an important precondition for developing new geofencing-based services.

(2) Munich is demonstrating how cities can successfully collaborate with e-scooter operators to develop safer and more accessible micro-mobility solutions. New regulations adopted in 2022 aim to prevent e-scooters from being parked where they can obstruct or endanger pedestrians, especially people with mobility impairments. The city has data-sharing agreements with e-scooter operators; the data gives insight, and a dashboard is used to monitor, create and communicate geofencing zones.

(3) Gothenburg is demonstrating lower speed limits in vulnerable areas in their special transport services. They are interested in understanding how geofencing services like speed control can aid the drivers and looking into how these services can be procured. This is an important step for cities to show that they are taking proactive measures to improve traffic safety for users such as schoolchildren and the elderly.

Complementary surveys, interviews and literature studies were conducted in the use cases. Also, surveys and interviews were conducted in 2021/2022 on the challenges and needs of European cities in using geofencing for urban traffic management [2].

2. Learnings

This chapter summarises key learnings from the use cases and complementary surveys, interviews and literature studies described in 1.2. The learnings are divided into different categories policy and regulation, transformation capacity and readiness of underlying capacities. Lastly, there is a subsection summarising some of the key learnings from the interviews and surveys conducted with transport and traffic experts representing the public sector, in different European countries.

2.1 Policy and Regulation

There is no legislation that directly prohibits geofencing. On the other hand, there is also no legislation that explicitly allows it, although there are exceptions in some countries. This means that different actors need to find their own way. However, there are rules that affect the chosen solution, such as GDPR (EU 2016/679). The GDPR governs how personal data is allowed to be collected and used, which can be particularly challenging for a city. The city often does not want personal data but only aggregated data from users. This means that the chosen geofencing solution needs to meet this need. The city may also want to procure vehicles or transportation services that are geofenced. One lesson from the GeoSence project is that the technology is not yet ready for large-scale procurement, but that more pilots are needed regarding this matter. Currently, it is possible to procure solutions based on retrofitting of vehicles from 3rd parties, but these solutions so far require personalization of vehicles for the technology to work.

2.2 Transformation capacity

Access to and harmonization of data is a critical prerequisite for new applications and innovations in geofencing to emerge in the city. However, harmonized data and data availability alone are not enough for geofencing to significantly influence the city's transport and mobility ecosystem. In an analysis of the city of Stockholm, we see that another key factor is the city's ability and capacity for transformation in this area. This transformation ability is a combination of data management-, digitalisation-, and innovation capacity, combined with the city's ability to work horizontally and mitigate internal lock-ins while improving collaboration with external actors. By exploring geofencing as a technology, we see that the city can make significant progress in preparing for the sustainable mobility of the future by enhancing its ability to apply innovative geofencing solutions. If the city is in parallel and at the same pace are strengthens its overall transformation capacity.

2.3 Readiness of underlying digital technologies

Positioning

Implementing geofencing requires a technical device to accurately measure a vehicle's spatial position and a digital system to process the geofences and geospatial information. Position data for geofencing is typically collected via Global Navigation Satellite System (GNSS). The spatial accuracy of modern GNSS sensors is about 1-3 meters under ideal conditions but it can be affected by various factors (e.g., tall buildings, tunnels, or dense urban environments), introducing position errors of several meters.

The use cases in Gothenburg and Munich illustrated the challenges posed by GNSS inaccuracies. In Gothenburg inaccuracy led to issues with the detection performance for a geofencing-based retrofitted Intelligent Speed Assistance (ISA) system. When two roads ran closely alongside each other - one within and the other outside a geofenced area - the system sometimes triggered erroneous feedback (i.e., false positive or false negative errors, both resulting in wrong speed limit suggestions). Even though this occurred rarely, it affected the perception of effectiveness and acceptance among the participating drivers negatively. However, the collected data offers the chance to identify and analyse such issues and to adjust and improve geofences and system functions.

In Munich, parking zones for e-scooters were geofenced. The inherent limitations of GNSS accuracy together with the small dimension of the parking zones (2 x 10 m) cause a low reliability to detect an e-scooter within a parking zone. To prevent this, a tolerance range (approx. 20 m) is therefore applied to verify correct parking. Nevertheless, users experienced that e-scooters could not be returned despite standing within a parking zone, and in other cases e-scooters were returned in non-parking areas outside a parking zone. Presently, GNSS accuracy often falls short of providing reliable data to regulate e-scooter parking in urban settings. Therefore, additional sensor technologies are currently being tested worldwide to enhance the accuracy of the position signal.

The second prerequisite is a technical solution to process position and geofence information to generate feedback for drivers and/or to enable direct vehicle control functions (e.g., speed regulation or permitting/rejecting e-scooter parking). This can be achieved either by an on-board digital device using pre-installed data (e.g., maps and geofences) or by sending the data via wireless broadband communication to a cloud-based service for processing and subsequent feedback information. The former approach demands more technically complex systems but provides more or less real-time performance. The latter method is suitable when temporal delays of several seconds between data transmission and reception are not critical for performance.

A prevailing challenge for geofencing implementations is the absence of standardized application interfaces and that few geofence solutions are available in new cars. Existing solutions are often closed systems with proprietary OEM-specific APIs for fixed functionalities. Retrofitted hardware is currently the only viable option for implementing geofencing solutions in a heterogeneous vehicle fleet, but applicability may vary. Barriers include elevated costs for retrofitted equipment and expenses for equipment installation, mobile data usage, and third-party services as well as potential issues concerning insurance and warranty rights.

Digital platforms

Digital platforms are required to implement geofencing solutions in a meaningful way within an authority. The digital platforms are used to create and manage geofences and their policies in an easy and seamless manner, integrating it into existing digital processes and workflows, and processing data that enables the analysis, control and further adaptation of geofenced-based regulations (data for governance).

Our work in GeoSence revealed two ways in which authorities find appropriate digital platforms. One reported approach is that authorities develop digital solutions on their own, relying on open (source) and partly self-developed software, standards or data interfaces. The solution in this particular case was initially developed in an innovation project by a municipality in Norway and later used by other cities in the country. It provided digital maps with different layers of information for e-scooter companies including regulations for speed, access, parking and vehicle fleet size restrictions.

However, most municipalities will probably rely on procuring a commercial digital platform solution through a public tender. Especially for the micro-mobility sector (but also in the transport management sector) a number of commercial solutions have been developed in the past years. A commercial solution for geofencing in the micro-mobility sector has been implemented by Munich's mobility department. The solution allows the definition and management of geofences and their policies and provides functionalities to transfer the rules to the e-scooter providers in a standardized way. The dashboard solution also retrieves data about e-scooter usage and parking from the providers, can display them together with rules on a map, and integrates various tools for the analysis of the data. As solutions get more developed and mature with time this approach to integrate digital platforms is perhaps a more appropriate way for authorities, since it will require less expertise and human resources to handle technical and IT-related issues in the long run. Further important decision criteria for selecting a digital platform are scalability and interoperability to fit the needs of new or higher demands in future.

2.4 Challenges and needs for geofencing in European cities

Learnings from the interviews and surveys conducted with transport and traffic experts representing the public sector, in different European countries [2] are in line with the learnings from the GeoSence use cases. Some of the key learnings are:

(1) *Potential, risks and barriers* – One of the potential things mentioned are a need of fewer signs and maintenance, leading to more efficient traffic regulation. One risk mentioned is that transport companies will use geofencing solutions mainly to buy one's way of access in the transport system. One barrier mentioned is the limited economic resources in municipalities to make this transition. (2) *Acceptance and stakeholder involvement* – Acceptance of geofencing for traffic management is easier with stepwise implementation for shared types of transport, starting with smaller pilots before scaling up. Successful implementation also requires multi-stakeholder collaboration, including private entities, the public sector, research, and the users. For instance, it is important to involve the right stakeholder with the required competencies at the right time, e.g., to set geofencing zones. It is also crucial to start with the user needs, rather than with the technological solution. (3) *Agreements and regulations* – Voluntary agreements between e.g., municipalities and mobility operators are one way to implement geofencing solutions, and if done correctly can develop the relation between the actors. The problem is that with voluntary agreements, the municipalities cannot guarantee that the

operator will comply with the proposed measures. In some cases, new transport modes such as e-scooters can benefit from clearer regulations making it both clear for the operator what they need to oblige with, and also making the space of enforcement for the municipality clear e.g., to what degree they can demand that operators use solutions, such as geofencing. (4) *Data* – It is important that there is access to desired data, that it is of good quality, that the data is updated frequently and that the data format used is interoperable and standardised. In some cases, municipalities, are setting their barriers own by not providing access to the desired data. Data sharing platforms for sending and receiving data make setting up and communicating the zones more efficient.

3. Discussion

A basic premise for a geofence to reach its purpose is to have a marked-off area in a digital map, and this area must contain a rule or regulation differing for the area around. But to apply such a solution demands a vast set of factors for geofences to be fully implemented, A geofence use case is not only a technology or bundle of technologies but a system. Learnings from this project show us that for geofencing to accelerate the transition of urban management there is a need for a systemic approach that takes into consideration both the technology and the social context [3]. Geofencing could contribute to removing speed signs, remove parking signs – thus contributing to less infrastructure, it could make traffic more efficient and flow better, and even pollute fewer chosen areas. But a new digital system of transport management with geofencing, how can we get there? Our findings show that the main drivers and barriers can be related to the configuration of technological, institutional, and social functions. These are related to the readiness of underlying digital technologies such as for positioning and digital platforms, but also updated and shared data (technology), policies and regulation (institutional), and the transformative capacity, which means among others competence and knowledge (social). Depending on the use case of geofencing and the stage of implementation, the configuration of these three must be optimized. E.g., involve the right stakeholder with the required competencies at the right time. This example shows the need to develop the technological & institutional functions and the technological & social functions in alignment The transformative capacity of Stockholm is a good example - combining innovation capacity together with the knowledge exchange and collaboration to move forward and accelerate the digital transition.

References

1. Hansen, L., Arnesen, P., Graupner, S,T., Lindkvist, H., Leonardi, J., Al Fahel., Andersson, K. *Current state of the art and use case description on geofencing for traffic management* (2021). ISBN: 978-82-14-07729-2
2. Hansen, L., Graupner, S,T., Leonardi, J., Lindkvist, H., *Challenges and needs of European cities in using geofencing for urban traffic management* (2022). ISBN: 978-82-14-07576-2
3. Geels, F. W. (2005). *Technological transitions and system innovations: a co-evolutionary and socio-technical analysis*. Edward Elgar Publishing.