Who is part of geofencing? Actors: their roles and interactions in connected freight transport systems

Keywords: Industrial network approach, roles, developing setting, transport, ITS, geofencing, coordination

INTRODUCTION

Mitigating the negative effects from urban freight transport but still sustain accessibility, mobility and business operation is a major challenge for larger cites (Behrends, Lindholm, & Woxenius, 2008; Quak & Tavasszy, 2011). New tools for Intelligent Transport Systems (ITS), enabled by Information and Communication Technologies (ICT), are emerging. These tools aim to overcome this challenge, contributing to low emitting, safer and more attractive urban environments, without having a negative impact on transport and business operation (Agarwal & Alam, 2018). However, even if these tools have high potential to contribute to sustainable freight transport systems, they are rarely implemented on a larger scale, due to lack of clear business models (Asselin-Miller et al., 2016) and lack of collaboration and coordination between actors (Turetken, Grefen, Gilsing, Adali, & Ozka, 2019). Furthermore, ITS often rely upon several crucial factors, such as multiple actor collaboration, data sharing, new business models, private-public interaction, introduction of new actors and shift in roles for existing actors (Cooper, Tryfonas, Crick, & Marsh, 2019; Leviäkangas & Öörni, 2020; Whittle, Whitmarsh, Haggar, Morgan, & Parkhurst, 2019; Zlocki, Raudszus, Eckstein, & Lu, 2019). Deployment of technologies for ITS demand understanding of these aspects. Also, digitalization and connectivity grow more important for more sustainable urban freight transport systems. ITS entails that more organizations interact, often in new ways and with new actors, which imply that aims and expectations become more complex (Håkansson & Snehota, 1995).

A technology within ITS that portraits all these aspects is geofencing. Geofencing is defined as the delineation of a geographical zone by a geolocated virtual perimeter which automatically detects when tracked mobile units (phones, vehicles, etc.) enter or exit these areas with the help of geopositioning (GNSS/GPS) (Reclus, 2013). For traffic related applications this implies that a virtual perimeter detects when a vehicle or other road users enter or exit a geographical defined area and triggers some kind of action in or outside the vehicle, such as toll payment, switch of powertrain in a hybrid-vehicle, warning signaling and speed adjustment (Foss, Seter, & Arnesen, 2019). Although geofencing is considered to contribute to increased social and environmental sustainability, it is still in its infancy and little is known about the emerging roles of both existing and new actors or how different actors interact.

With this paper, we aim to investigate the emerging actor roles in industrial networks of geofencing-applications for freight transport. Therefore, we have developed three research questions (i) which are the key actors and stakeholders and what are their roles in a geofencing network? (ii) which interactions are taking place between these actors? and (iii) what motivations or drivers do these actors have to join these networks?

In order to investigate these networks, we conduct a case study, which allows us to explore a number of actors within geofencing-applications and their interactions within the network. Hence, by answering these research questions, we will expand the knowledge about the organizing of geofencing and how its technological development is enabled thorough interaction between actors. Our study shows that the common base is in place in developing geofencing based on the study of the ongoing Swedish initiatives including private and public actors. There are also individual differences among and within actors regarding their drivers, as well as how they foresee development of key resources and interaction with other private and public actors.

The field of research within the transport system has few studies focusing on the application of geofencing within freight transport. Therefore, we have developed some research issues that need to be further investigated in future studies. These entail perspectives on processes for developing common resources such as physical and digital infrastructure, systems and applications in relation to ownership and common and individual goals. The paper is structured as follows. First a theoretical frame of reference is presented. Following is a description of our chosen methodology. Thereafter, the empirical study is presented and an initial analysis is made. Finally, concluding remarks are provided, including a number of future research issues.

THEORETICAL FRAME OF REFERENCE

In order to analyse the changes in the transport system when introducing ITS, this paper builds on the Industrial Network Approach (INA) to business markets as the frame of reference. Given that the focal study object, geofencing, is still under development, this paper primarily focusses on network perspectives in the developing setting. Below, first INA is described, followed by the developing context of business networks.

Industrial Network Approach

INA can provide fundamental understanding of the various actors, activities and available resources and resource combining for value capture for several actors in complex business networks. Business relationships are described as long-term, characterized by complexity and mutual adaptations among the parties (Gadde & Håkansson, 1993). Business relationships influence and are influenced by other business relationships which forms the base for business networks. For analytical reasons, business networks have been separated into activities, resources and actors – the ARA model for analyzing networks (Håkansson, 1987). Actors control resources and undertake activities through using resources. Always in business networks, interaction among actors and actor bonds form a key feature (Håkansson & Snehota, 1995). The resource dimension includes different types of resources, such as, products, facilities, people, and IT systems and resources are tied in relationships (ibid.). What is distinguishing for resources is that the value of resources depends on how they are combined with other resources. Also, resources are developed in interaction with other resources (Baraldi, Gressetvold, & Harrison, 2012).

The developing setting of networks

To understand the development of resources in business networks, three business network settings have been proposed, *developing*, *producing* and *using* (Håkansson & Waluszewski, 2007; Ingemansson, 2010). First new resources need to be developed, to be produced in order to be used. The actors involved in the three settings can be overlapping or different. This paper focus primarily on the actors, activities, drivers and the emerging roles in the developing setting of geofencing in urban freight transport systems. The developing setting entails innovative aspects which soon proliferates into new ideas and activities. These ideas can take different, both parallel and divergent paths in the development of a new product or service (Van de Ven, 2017). This implies that the outcome is never certain. Furthermore, the development setting entails innovative aspects, which in complex settings often require interorganizational collaborations to co-create value for participating actors, which implies a shift from firm-centric innovation to network-centric innovation (Coughlan, 2012). Due to these circumstances the geofencing network is interesting to study from a developing setting perspective.

METHOD

In order to study the industrial network within geofencing-applications for freight transport this study has a case study approach with interviews as the main data collection method. The case study approach is suitable to understand and handle complexity of networks, links among actors and to understand the development of network changes over time (Easton, 1995).

The base for our study is Sweden, as it is a country that is leading in the development of geofencing in traffic related applications, as well as its implementation. The technology has been tested with different applications in several different innovation projects, mainly in the cities of Gothenburg and Stockholm. In Stockholm different tests with silent nighttime deliveries for city distribution with the help of geofencing has been carried out. In Gothenburg different applications have been tested, both related to speed reduction and environmental zones. A number of other projects are ongoing in these cities, which intend to test geofencing to secure speed in certain zones for e-scooters, public transport and freight vehicles. In Stockholm this include allowing heavy vehicles to drive on roads that are normally not allowing such heavy vehicles, but due to geofencing technology these vehicles can be assured to run on a lower speed to reduce damage on the infrastructure. In Stockholm tests are also being planned for dynamic speed adjustments at Hornsgatan for freight vehicles. Furthermore, the Swedish ministry of infrastructure has issued two governmental assignments to investigate geofencing and how it could be incorporated into legal frameworks in Sweden. Due to these circumstances, the Swedish case is currently most rewarding when wanting to study networks, actor interactions and activities related to various geofencing applications for freight transport in urban and public-private settings.

Data collection has mainly been made through interviews. Prior to beginning the interviews, an interview guide with open-ended questions was developed. The interview guide focused on the respondents' views and perspectives on geofencing, what their role in the development of geofencing are, what activities takes place and which actors that are involved in the geofencing network. Respondents were sampled by the use of a Swedish network of organizations participating in projects involving the use of geofencing. To be more specific, the identification and selection of people to include in the study was mainly derived from the ongoing geofencing research and innovation program which was established in Sweden 2018. In this innovation program, both public and private organizations take part to establish collaborative formats to develop and introduce geofencing as a tool for traffic management. Connected to this program are several ongoing projects which develop, test and evaluate different geofencing-applications, mainly in relation to traffic safety and environment. Hence, knowledgeable respondents from multiple organizations that participate in these networks were selected to be interviewed in our study.

A total of 17 semi-structured interviews with 24 unique respondents have been conducted with respondents from both public and private organizations who are either involved in various projects for geofencing development or in strategic positions for freight transport planning and development as well as service development and distribution. In some interviews more than one respondent participated from an individual organization, as shown in Table 1. Due to the circumstances of the ongoing Covid-19 pandemic the interviews were conducted on digital platforms between December and February in 2020-2021. All interviews were recorded and transcribed. In addition, secondary data has been collected, consisting of observations from various workshops, meetings and seminars that discuss geofencing in relation to urban freight transport. Also, documents, reports and information from participating organizations' homepages have been studied.

Table 1. Type of organizations and participants in interview study

Type of organization	*Number of interviews*	*Number of respondents*	*Positions of respondents*	*Respondent*
Public authority (local)	5 (two cities in study)	6	Freight strategists, project managers, Strategist in traffic development, Senior advisor business transports	R1, R2, R3, R5, R6 & R9
Public authority (national)	1	1	Head of investigation geofence and ITS-development	R15
Vehicle manufacturer	6 (from 4 independent vehicle manufacturers)	11	Senior manager Research & Innovation, Consultants (project connected vehicles & business development), Market/Sales, Technical development, Product planning, System engineer	R8, R12, R13, R16, R17, R18, R19, R20, R21, R22 & R23
Transport service provider	1	1	CTO	R7
Service provider	3 (from 3 independent service providers)	4	Sales, Product manager, Business developer, Senior project manager	R10, R11, R14 & R24
Public owned companies	1	1	Smart city coordinator	R4

The transcripts were coded and analyzed throughout the data collection. Data was structured in mega matrices (Miles & Huberman, 1984) following our theoretical concepts within the INA literature, namely actors, resources, activities and interactions. We also identified drivers and motivations, as well as barriers for developing, implementing and participating in geofencing activities.

EMPIRICAL FINDINGS

The empirical context: Geofencing in Sweden

In Sweden, the discussions for using geofencing as a tool to control or manage traffic for increased safety and efficiency started due to several terrorist attacks in Europe where vehicles were used as weapons. After the terrorist attack in Stockholm 2017, the Swedish government issued an assignment to the Swedish Transport Administration to test geofence as a tool to increase safety in traffic and reduce the risk of vehicle ramming (Näringsdepartementet, 2017). The assignment resulted in a collaboration between the Swedish transport administration, the cities of Stockholm and Gothenburg and three Swedish vehicle manufacturers to test geofencing applications and to further see how the technology could be developed and introduced as a measure to reduce transport related accidents and environmental impact (Trafikverket, 2018). This has resulted in numerous projects in public-private contexts where authorities, vehicle manufacturers, service providers and service users work together in complex settings to develop and deploy the technology in a larger scale. Numerous urban use cases for freight where geofencing is applied has been identified. These rely on public-private collaborations and in different collaborations projects that are often funded by national agencies.

Geofencing from public and private perspectives

To be able to identify and analyze various actors and especially the roles the different actors have in the geofencing network, it essential to first set the primary premises of geofencing. That is, what it implies in an urban freight transport setting and how the different respondents relate to the concept. Overall, the respondents agree upon the technical definition of geofencing, that it is a digital tool to set geographic positioned information, either through polygons, circles or rectangles, and that when a connected devise enters or exit the defined area it triggers some kind of chain of information. Although what the trigger is or who defines the geofence is not always clear among the actors in the study. The difference in opinion often lies in what role the road authorities and cities will have in establishing and distributing geofencing data. This is one of the main queries in the development of geofencing and puts emphasis the interactions between public and private organizations in this network.

Most respondents, both public and private, focus on similar use case for geofencing, namely speed adaptation, shift of propulsion from conventional to electric on hybrid vehicles and access control in defined areas. All respondents from public organizations emphasize that geofencing is a tool to increase traffic rule compliance. Many private actors, such as vehicle manufacturers and service providers see additional use cases with the technology, mostly related to various fleet management services and optimal driving performance. Geofencing in these cases help fleet managers to keep track of the vehicles and ensure that vehicles follow pre-determined routes. One interviewed vehicle manufacturer has developed and deployed a service where the customer can define the geofences and the criteria that the vehicle should apply, for instance a certain speed limit or a zone with only electric propulsion (Respondent 8, 16, 17 & 18). However, the cases where cities defines the geofences and the rules within them and distribute these to the vehicles is only being made in closed small scale pilot projects and something that is seen as not realistic in a foreseeable time, at least not for freight vehicles.

The drivers for geofencing development

All respondents identify benefits of geofencing as a technology to influence vehicles behavior or to give some kind of informative action to a fleet manager. For the public authorities the main drivers lie within social and environmental benefits of traffic safety and lower emissions. "… the main point is how you want a city to be, which is clean, silent, secure, accessible and such things" (R2). In a similar vein, "You should create quiet and slow vehicles and there I think geofencing will be very central, and not only for trucks and buses but also for cars I would like to argue" (R9). Respondent 1 states that geofencing is an enabler for increased traffic safety and to make it healthier and more pleasant to be in cities. So, for public authorities the main objective with geofencing is to see to the interests and well-being of inhabitants, which is within their public mission.

Private organizations on the other hand have other interests to consider. Here the benefits for their customers are in focus, including lower maintenance cost, lower fuel consumption and longer up-times, which in many cases is the reason for developing geofencing. Private organizations see that there is still a small or in some cases no demand for the kind of geofencing-services that ensure that vehicles follow set traffic rules. However, several respondents state that the demand could come to increase and in those cases they need to be ready to deploy such services: "At the moment no one really knows what it [geofencing] is on the market, but in a couple of years it may be an established solution, and then we must have kept up with that train" (R11). This statement is backed up by another respondent who states that "The customers does not always see the possibilities with the new technologies, and that it is up to the service provider to understand the customer's needs and come up with solutions" (R21). Furthermore, many respondents, both public and private, see that the recent development in Europe with introducing more zero or low emission zones will increase the use of geofencing as hybrid vehicles can be allowed in these areas if geofencing enforce these to drive on electric mode. In the study several private actors, including vehicle manufacturers, see positive on this trend as tougher requirements from authorities indicates a faster change toward greener vehicles.

Actors activities and interaction for developing geofencing

We have identified the most important actors in our case study. These actors, their activities, who they interact with and their drivers are described in Table 2.

Table 2. Actors, activities, interactions and drivers

Actor		Activities	Interact with	Drivers
Public organizations	Local public authority	- Introduce digital tools for data sharing and check data quality - Policy implementation for roads in cities	- Road transport agencies - Vehicle manufacturers - Service providers of geofencing enabling technology - Transport operators (through procurements and policy implementation)	- Safety and well-being of citizens
	National road authority	- Share data on traffic and infrastructure - Policy implementation for state owned roads	- Road transport agencies - Vehicle manufacturers - Transport operators (through procurements and policy implementation)	- Safety and well-being of citizens - Not hinder market driven technology advancement
Private organizations	Vehicle manufacturers	- Develop and introduce geofencing service - Define business models - Develop API's/interfaces for geofencing applications	- Public road operators (local and national) - Customers/users (freight transport operators) - Map service providers - Depend on suppliers of services and products to enable geofencing-applications	- Market and technology - Create services that increase efficiency or reduce operation costs for customers - Increasing demand from customers on safety features and lower emissions
	Third party service providers	Provide additional services, often retrofit solutions	- Transport operators - Map service provider	- Create services that increase efficiency or reduce costs for customers
	Map-service providers	Provide map data services, mainly for private actors	- Vehicle manufacturers - Some cases public authorities	- Market and technology
	Freight transport operators	- Provide freight transport services - Buy or lease freight vehicles - In all cases at the moment defines the geofences in the tool provided by the service provider	Service provider & customers (shippers/transport buyers)	Reduced costs of operation & better work environment for drivers
	Shippers/transport buyers	- Set requirements on transport quality in procurements	- Freight transport operators	- Ensure quality of transport of their goods

INITIAL ANALYSIS OF ROLES IN THE GEOFENCING NETWORK

In analyzing the roles in the geofencing network, we find that the most dominant identified roles are *enablers*, *service providers* and *users*. In essence, public organizations, including local public authority and national road authority, are enablers and contributes with the "need of technology". Meanwhile, private organizations, such as vehicle manufacturers and third party service providers have the role as service provider. Map-service providers have the role as supplier to service provider. Freight transport operators are both service users and road user (affected by road policies). Finally, shippers and transport buyers have the role *encourager*.

Most respondents, both from public and private organizations, identify public organizations as enablers, meaning that they provide the necessary high-quality data to develop and implement geofencing technology. In some cases, they are also identified as the ones that defines and distributes the geofences. Some respondents see them as mere buyers of transport and that they enable geofencing by including demand of the technology in public procurements of the authority´s own needs of transport. In a similar way, transport buyers are indicated to have a central role in the deployment of geofencing. They can set the requirements in the procurements that indicates that geofencing as a tool is needed to meet those requirements. This role is categorized as *encourager*, meaning that they through different measures can encourage users to buy and use a geofencing-service. Another way to introduce geofencing is through transport permits, that vehicles that have cargo loads or vehicle size above legal limits must have geofencing-functionality in order to be permitted to use certain roads (R15). Service providers are actors that develop and commercialize geofencing-services. It can be vehicle manufacturers or third-party service providers that install hardware on the vehicles that enable various geofencing-functionalities. Users are the actors that in some way use and pay for the service, mainly transport operators.

In developing geofencing, the actors have different dimensions of interests to see to which can inflict on their role or activities. While service providers must relate to international markets, sometimes global, public authorities are more concerned with national and local interests. Many, including public organizations, realize the importance of collaborating with international agencies to ensure harmonized measures for geofencing. In some cases even collaboration with competitors is eminent:

> "And we're actually working with our competitors together because they have the same... […] …but we are actually working together to make this more accessible because what we build on top of that or other products we build on top of that information is proprietary. But we have the same interest to get this information in a form that is actually harmonized and standardized that we can all use" (R24).

CONCLUDING REMARKS AND FUTURE RESEARCH

Our empirical study concerns networks of actors in the development phase of how geofencing can be implemented in urban areas. A few test studies have been made and a few pilots are up and running in Stockholm and Gothenburg. Due to the nascent characteristics of these networks and the newness of the technologies used, a number of "unknowns" need to be further investigated. We have therefore identified a number of research issues that need to be further investigated:

- How can actors collaborate and organize in geofencing networks?
- What roles do different actors have and what are the boundaries of these roles?
- How does the network change when moving from development phase (temporary project setting) to producing and using settings (more permanent settings)?
- How does the different drivers and motivators of the involved actors influence the network?
- How does new technologies in urban traffic management inflict on inter-organizational collaboration and interactions, especially in public-private settings?

To conclude, geofencing is a clearly a case that depend on interaction between public and private actors. This paper has mainly been focusing on the developing setting (Håkansson & Waluszewski, 2007; Ingemansson, 2010) of geofencing which has several interesting findings. For instance, how the actors relate the emerging roles of existing and new actors in the network as well as how they define their own role and business model. For several of the involved actors, this is not clear, and it is a searching mentality among the actors to identify their and other actors' roles. This can be analyzed further. Furthermore, the empirical findings indicate differences in means and ends for individual and joint resource development (Lind, 2015) in terms of drivers from public and private actors. This can be analyzed further for understanding the emergence of actor interaction needed to realize the potential. In the context of ITS and geofencing in particular, even though the long-term objective often is similar among the actors, the means and indicators in this case differs as the actors have different perceptions on the roles of public and private organizations.

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