Geospatial Dashboards for Intelligent Multimodal Traffic Management

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***Abstract*—This paper presents the current status and future outlook of Traffic Management as a Service (TMaaS). TMaaS is an innovative web platform that provides a cloud-based vendor-neutral multimodal traffic management solution for small and medium-sized cities. Urban mobility data from several stakeholders and public service providers is integrated and visualized in a clean, intuitive and customizable interface for traffic operators and citizens.**

***Index Terms*—traffic management as a service, traffic management, urban mobility, smart city, data integration, data visualization**

I. Introduction

In recent years an increasing number of cities have considered ways to enhance their citizens' mobility and their quality of life, while simultaneously striving to reduce the number of accidents, the amount of traffic jams and pollution. Because of a lack of resources, in terms of personnel, budget or infrastructure, small and medium-sized cities have not yet been able to participate in this type of urban mobility management. Nevertheless, they also feel the need to better serve their citizens' mobility needs in the digital age.

Even if the city can invest time, money and effort in traffic management, they find that the existing solutions are predominantly focused on motorized traffic. These technologies are therefore not entirely suitable to stimulate the use of public transport or other sustainable alternatives [1].

To bridge this gap, we introduce the Traffic Management as a Service (TMaaS) project, which aims to provide a new generation of interactive traffic management dashboards for the traffic operators, along with personalized mobility services for the citizens. By leveraging existing open geospatial data from participating cities, potentially augmented with additional data feeds from commercial parties or information from different levels of government, TMaaS provides an affordable solution for small and medium-sized cities that are interested in mobility management with minimal effort.

The resulting platform aspires to be a flexible, lightweight, multimodal traffic management system. It aims to complement existing traffic control centers so that larger cities that already monitor or manage traffic flows can also benefit from TMaaS. It acts as a platform for real-time monitoring, long-term mobility analysis and communication with the citizens. The open architecture is designed to be data and vendor-independent.

TMaaS has been implemented for the city of Ghent, Belgium (see Figure 1) and in the coming months the system will also become operational in Antwerp (Belgium), Southwark (United Kingdom) and Duran (Ecuador). So far, the project has been awarded the CIVITAS Bold Measure Award 2018 [2] and the Belfius Smart Belgium Award 2019 [3].

This work is structured as follows; in Section II, we introduce the TMaaS project and its goals and requirements. Next, we introduce the Mobility Management as a Service architecture that was developed to support TMaaS, followed by an explanation on the data sources, and more detail on the ongoing experiments and results in Section V. Finally, we look at the practical setup of the demonstration that we envisage for PerCom 2020.

II. Traffic Management as a Service

TMaaS is a traffic management framework that was primarily designed for small and medium-sized cities. These cities with more than 50.000 and less than 250.000 inhabitants [4], experience several problems with the traditional traffic management approach. First, urban mobility has become quite complex, with multimodality and sustainability gaining importance, while current systems focus primarily on motorized traffic. Existing solutions also suffer from vendor lock-in and a lack of cross-compatibility. Finally, the high infrastructure and software costs, along with expensive and ambiguous data licensing conditions are prohibitive for smaller cities.

TMaaS therefore presents a considerable innovation in traffic management. It brings together a number of data providers, urban authorities, stakeholders, research institutions and SME's to collaborate on the development of the TMaaS dashboard.

With limited investment, traffic managers will be able to have a better awareness of the current traffic situation, to monitor specific road segments and to act quickly in case of disturbances. The operators can also validate, edit and remove traffic events in function of a fast, reliable and useful communication towards citizens about mobility in their area of

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interest. Traffic events are geolocated points or road segments where the typical traffic is disturbed, for example due to car accidents or disruptions in public transport. The changes made by the traffic managers will not only be visible in the dashboard, but also be forwarded to the data providers, so that other services can also benefit from more accurate traffic incident data.

Citizens, on the other hand, get access to tailored and customizable viewports on the TMaaS dashboard. These viewports along with the personalized alerts are based on their own mobility profile [5] that is generated based on 18 *golden questions* that were proposed by Anable *et al.* [6], allow citizens to get an idea of potential problems that they might face along their typical routes, and can help them to decide whether they need to change their departure time or look for alternative means of transportation.

A. Requirements

Extensive surveys of existing traffic management centers in 6 cities of varying size and technical know-how around the world, along with a set of co-creation workshops and user tests performed with citizens of Ghent, have shown that an effective traffic management service must adhere to a number of key requirements [7]. Some stakeholders consider certain requirements more critical than others [8].

For cities, it is important that new initiatives are maximally compatible with existing solutions, so that authorities that already have access to traffic management tools, data sets or smart city sensors can be accomodated. The TMaaS research teams have shown that an effective traffic management architecture must also be flexible enough to effectively support them no matter how limited or extensive their traffic management activities are (activities in traffic management centers range from solely traffic monitoring to full scale traffic management).

To cope with varying interest rates of citizens towards the platform (e.g. during extreme weather events people are more likely to check the viability of their commute in the morning), and different types and sizes of data, the system must be scalable to minimize latency and delays with data delivery.

III. Architecture

To meet these requirements, TMaaS implements the Mobility Management as a Service (MMaaS) framework [9]. The architecture is composed of four layers that exhibit different data characteristics. In Level 0 (L0), data that enters the framework first passes a licensing check and a couple of pre-processing steps that ensure that the data quality can be guaranteed to the standards required by the urban authorities.

The data is standardized in Level 1 (L1). There, it is converted into one of the generic acceptable data formats. The current list of data formats is extensible, and should enable the integration of additional well-defined transportation data sets later. Data that was marked as license-encumbered can be processed by a neutral third party, who accomodates the requests of any commercial party, respecting their licensing rules. The licensing information propagates up the chain along with data quality information. The output of these standardization processes is made available through APIs so that it can used by external data consumers, such as local app developers or logistics companies.

A number of data integration and analysis tools exist in Level 2 (L2), which are used to intelligently join or augment data sets to create new insights that are useful to citizens or traffic managers. The results of these analyses can also be retrieved by external parties via APIs, provided that the licensing rules allow sharing this information.

At the highest level (L3), the data and insights are visualized on intuitive and flexible dashboards. Personal views can be provided based on the preferences of the citizens or the operators, and the system also allows to uniformly visualize data from different providers and commercial parties on a single map view. The analytics, combined with information about the citizens can also be used to dynamically generate personal alerts that advise them about alternative routes or transport modes for their commute to work, for example.

Participating cities can also opt to link certain communication channels to the application. This communication can potentially work in two directions; it allows citizens to contact them to report issues on the road (e.g. potholes or traffic congestion), while simultaneously allowing operators to inform all citizens of major disturbances, such as public transport strikes or heavy snowfall.

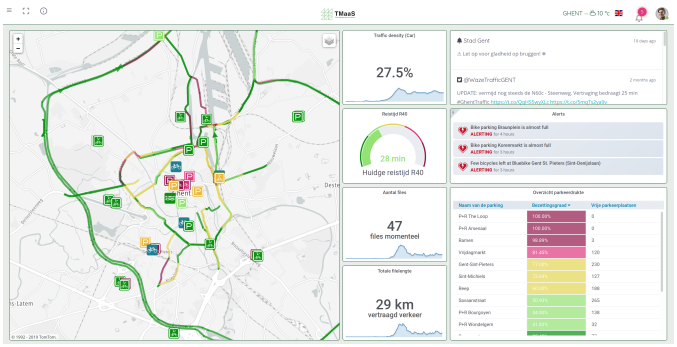

Fig. 1. An example of a TMaaS end user view (Ghent, Belgium) at the time of the first prototype.

IV. Data sources

A large amount of data from various sources and stakeholders is retrieved, stored and augmented for visualization on the TMaaS dashboard. The Ghent Open Data Platform provides point information on bicycle services along with the location and live occupancy of car and bicycle parking garages [10]. TomTom, Waze and Be-Mobile provide travel times along specific routes and traffic incident information using the DATEX II format [11] with OpenLR encoding [12]. The local public transport providers can provide real time data on bus or train delays via GTFS(-RT) or NETEX. Several data sets that provide the live availability and location of local car and bike sharing providers have also been integrated. The public road authorities have provided live speed and vehicle count

data from counting loops in and around Ghent. This data is made available for visualization and for re-use by interested external parties through a number of public APIs.

V. Prototypes

Over the course of the TMaaS project, four iterations of the tool are being developed. The first research prototype, which was released in early July of 2019, was used solely by Ghentian traffic operators. A second prototype, which was released in December 2019, focuses primarily on the citizens. The third prototype, which will be released in Q1 2020 will combine the aspects developed for the traffic operators with those developed for the citizens. Finally, the fourth prototype will enable TMaaS for the three aforementioned replicator cities and will be released later in 2020.

A. First prototype

The first prototype of the TMaaS dashboard was tested by traffic managers during the Ghent Festival, a yearly event that takes place within the inner city, drawing roughly 1.5 million visitors over a period of 10 days. In the past, the traffic operators used a variety of different tools and applications from different providers to manage the car traffic. The goal of the first testing phase was therefore to see whether they were able to use the TMaaS platform to more effectively and intuitively manage a more diverse set of transportation modes. To evaluate this, the traffic operators logged their actions on the TMaaS dashboard and filled out a document with issues they encountered, along with potential improvements that they envisaged.

At the time of this prototype, we had incorporated 17 different data sources, ranging from TomTom traffic events to live availability of bike sharing facilities in Ghent. This data was visualized in 26 widgets and KPIs (Key Performance Indicators), spread over 3 thematic viewports and also on relevant map layers. The response to the first prototype was generally positive. 74 issues and suggestions of varying priority (21 high, 23 medium and 30 low) were logged by 5 traffic managers. The TMaaS dashboard was stable and the traffic operators experienced no technical difficulties during the test phase. The operators reported that the map view needed improvements to clearly show the severity of traffic incidents, that certain data feeds refreshed too infrequently and that the dashboard viewports provided in the prototype were not flexible enough. These deficiencies have been resolved for the second prototype.

B. Second prototype

The second prototype, which is still under development at the time of writing, will enable more advanced functionalities for the citizens of Ghent. Their default dashboard viewport will be tailored to their mobility behavior, so that public transport dependants are not informed of car parking occupancies, for example. The citizen can alter their default dashboard by adding or removing widgets as desired. Additionally, they will receive notifications if disturbances occur along their frequent routes. Additional surveys will be carried out to ensure that the provided functionality aligns with the needs of the end users during the second test phase.

VI. Practical setup

At PERCOM 2020, we will demonstrate the capabilities of the TMaaS framework in terms of data integration, data aggregation and data visualization. One of the goals of TMaaS is also to provide flexible, personalized dashboards for citizens.

Therefore, people will be able to experiment with our personalization tools. At the booth, we will demonstrate the online TMaaS dashboard for Ghent. Interested visitors will also be able to create their own personalized dashboard, based on their mobility profile.

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