JCT2019 Symposium, Nottingham, United Kingdom, 17-18 August 2019

Smart Traffic - A Discussion of the Results From the Netherlands

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Abstract

Traffic congestion is a growing and global problem, impacting the majority of people traveling and goods moving in urban areas around the world. Cities are challenged to keep traffic flowing, reduce pollution and decrease the economic damage caused by congestion. Predictive technology will play a significant role in the cities of the future. An era of solutions using the wide range of collected data will bring new opportunities and efficiencies. Next-generation technology for Traffic Light Controllers is based on real-time data fusion through a real-time traffic model. Rather than emptying queues like traditional controllers, each vehicle approaching the intersection is detected and its arrival time forecasted. Based on these forecasts the most efficient schedule is calculated, increasing the throughput significantly. Along with the optimisation it is possible to prioritise bicycles or trucks, as part of road authority policies and objectives to reduce pollution or encourage the use of certain modes of transportation. This paper describes on-street results and the experiences with various use cases.

Keywords:

Traffic Light Controllers, Real-Time Traffic Model, Traffic Optimisation, Forecasting.

The challenge

Urban areas experience a continuing growth in inhabitants. Today around 60 percent of European citizens live in urban areas (cities with over 100.000 inhabitants). Due to further urbanisation this number is expected to rise to 70 percent or more, while the total number of EU citizens will increase as well. Due to this the liveability in cities will be under pressure, while there is an ongoing focus on a cleaner and more sustainable city. Considering mobility alone, more inhabitants means more traffic, more congestion and a higher risk of accidents, resulting in even more congestion. This results in more pollution, decreased safety, higher costs and hence reduced liveability. Solving these issues is the main priority for Smart Mobility[1].

Collecting data (Big Data) is an ongoing hype in urban areas. However, the number of applications that actually use the data is rather limited. This is unfortunate as combining the collected data for use in applications has the potential to improve liveability. There is a movement needed that does not think in data but in solutions. The urban area is covered with millions of traffic sensors ranging from induction loops, cameras, Wi-Fi sniffers, Floating Car Data (FCD), etc. Most of the time these sensors are deployed with a very specific and limited use case. An example is the usage of loop detectors for traffic lights. With the movement of making this type of data available in real time new opportunities arise. In this paper we discuss the new generation of traffic control software that is already doing this and its effects.

Traffic optimisation

In the field of Traffic optimisation there is a lot that can be improved, ranging from the optimisation of current throughput, deployment of predictive traffic management services, providing in-car information about time-to-green and time-to-red, up to making traffic lights communicate to the self-driving vehicle. In the Dutch city of Helmond a pilot location was chosen to deploy predictive software and to test these services. The pilot site is in city centre of Helmond, showing a typical Dutch mixed-use street with cyclists, pedestrians and car traffic. In September 2018 the Sweco Smart Traffic software was deployed on a Siemens Traffic Light Controller. Figure 1 shows the Helmond location.

Figure 1 – The typically Dutch street situation in Helmond

Current Traffic Light technology is all about detecting and serving waiting vehicles at the intersections, mostly in a fixed sequence. Waiting for a vehicle to stop and a queue to form before serving the direction results in additional waiting time, pollution and road wear. There is no effective use of other data sensors and novel data technologies. Prior to the deployment of Smart

Traffic this was also applicable for this location. Please note that using FCD requires additional measures in order to ensure privacy of road users[5].

Making the hardware ready

The Traffic Light Controller (TLC) in Helmond is a TLC from Siemens. This TLC is running a local program (CCOL) with a fixed schedule of serving green. This CCOL program is vehicle actuated. Besides the program there is a prioritisation system integrated for public transport. This is done via short range radio messages. The TLC is equipped with hardware in order to receive these messages.

TLC software was upgraded in order to enable certified cloud based third party applications to take over control. Also a 4G modem was deployed, which functions as a back-up connection in case the wired network fails or faces high latency. Please note that the TLC retains all its safety measures. In case an unsafe command is received from the third party, the TLC will refuse the signal change and instantly take over control.

Making the software ready

The cloud based signal control software, called 'Smart Traffic', is provided by Sweco. Smart Traffic is a certified software module that takes over control from the TLC. It is based on a real-time (big) data fusion model through a microscopic real-time traffic simulation model. The software does not wait for queues to form at the intersection, but instead its traffic model is able to forecast the arrival of each unique vehicle. Based on these forecasts the most efficient schedule is calculated, increasing the throughput significantly. Along with the optimisation it is possible to prioritise bicycles or trucks, as part of road authority policies and objectives to reduce pollution or encourage the use of certain modes of transportation. Further optimisation can be reached by combining multiple intersections into one network and the addition of a broad set of diverse data, e.g. Extended Floating Car Data (xFCD) or WiFi-sniffers.

For this location in Helmond Smart Traffic software is using existing loop detectors, the bus priority system (KAR) and available Floating Car Data and Floating Bicycle Data, made available via various Talking Traffic partners. Talking Traffic is a partnership between various commercial and public parties to share mobility data and utilize the Dutch mobility network in the most optimal way.

Results

Smart Traffic has been compared to the default CCOL software in a simulation environment, using PTV Vissim microsimulation software. Traffic volumes for average Tuesdays and Thursdays were supplied by the municipality and were used to calibrate the network. CCOL and Smart Traffic were each connected to the Vissim network and used to control the signals on the intersection in both morning and evening rush hours. Figure 2 shows the network that was used, which includes both bicycle and pedestrian lanes.

Please note that the use of FCD has not been taken into account in this analysis. However, it is expected that the effect of Smart Traffic will be even more pronounced when using FCD, as the predictive model is fed with more refined data than just loop detector data. Analysis in a project for Eindhoven shows that as the quality and quantity of data sources grows, predictive software like Smart Traffic performs better.

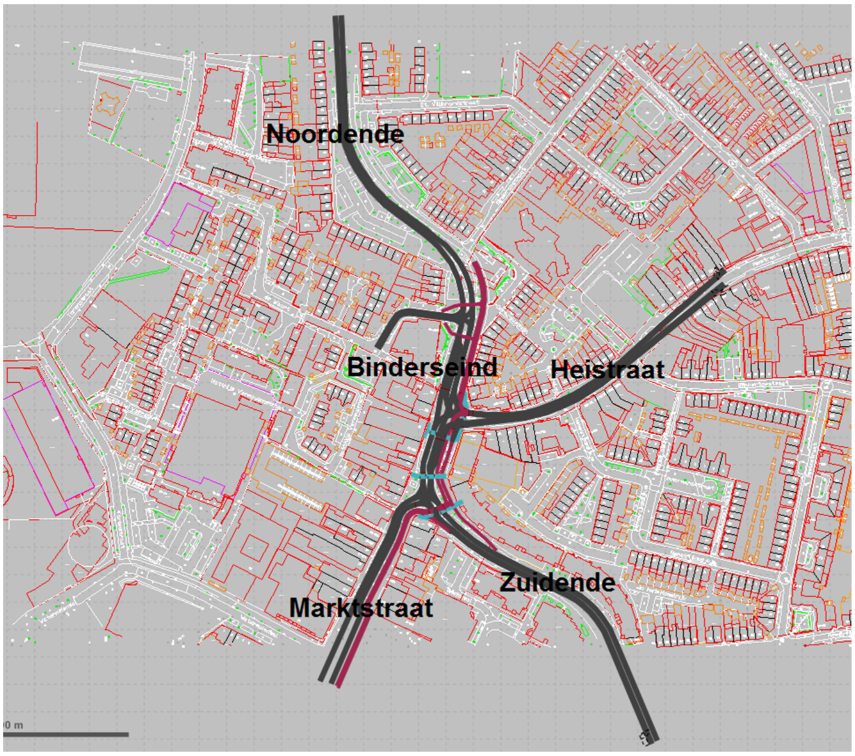

Figure 2 – The network used for comparison

For Smart Traffic default values were used with regards to optimisation and priorities. This means that no group of users (e.g. cyclists) was prioritised over other groups. Only public transport priority was taken into account.

The results show a reduction in accumulated delay for car traffic of 22%. Cyclists see a minor increase in accumulated delays when using default values. Figure 3 shows the average delay time for car traffic, displaying an ongoing reduction of delay times when using Smart Traffic, caused by the predictive bases Smart Traffic is using to control the TLC.

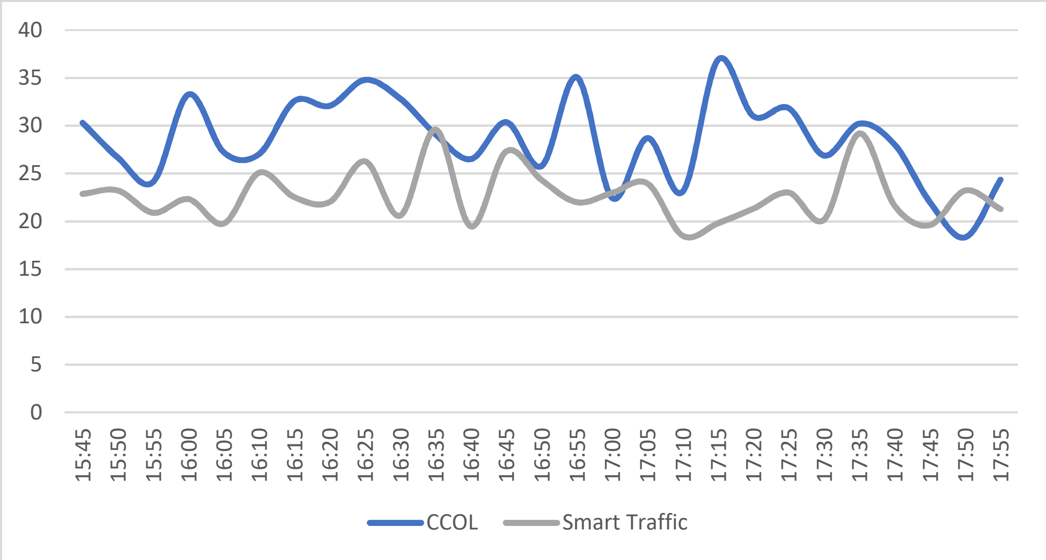

Figure 3 – Average delay time for car traffic, in seconds

A similar analysis has been done for cyclists. Results show that they need to wait slightly longer when Smart Traffic is used, on average between 2 and 3 seconds longer. Please note that this is caused by the fact that cyclists are not prioritised, but also due to the fact that there is limited detection available to detect cyclists approaching the intersection.

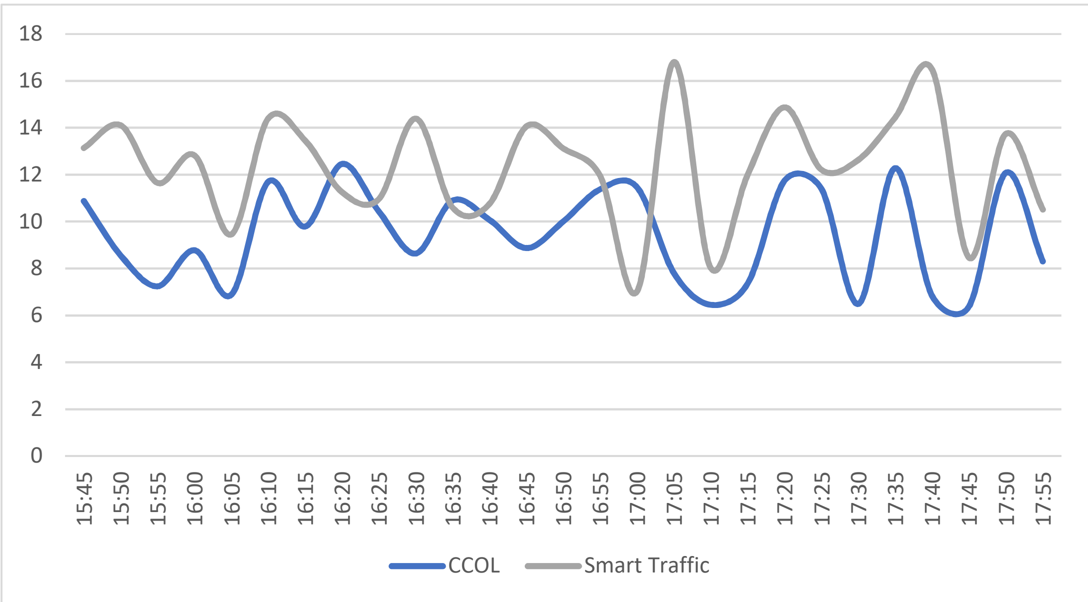

Figure 4 – Average delay time for cyclists, in seconds

Besides accumulated delay and average delay, the number of stops and length of queues were evaluated. Specifically the number of stops is relevant due to ambitions regarding CO2, NOx and PM10 emission reductions. Statistics show a slight reduction in the number of stops for car traffic using Smart Traffic (figure 5), bringing benefits to the liveability around the intersection. Further analysis is planned, using PTV Enviver to translate these results into accurate emission statistics.

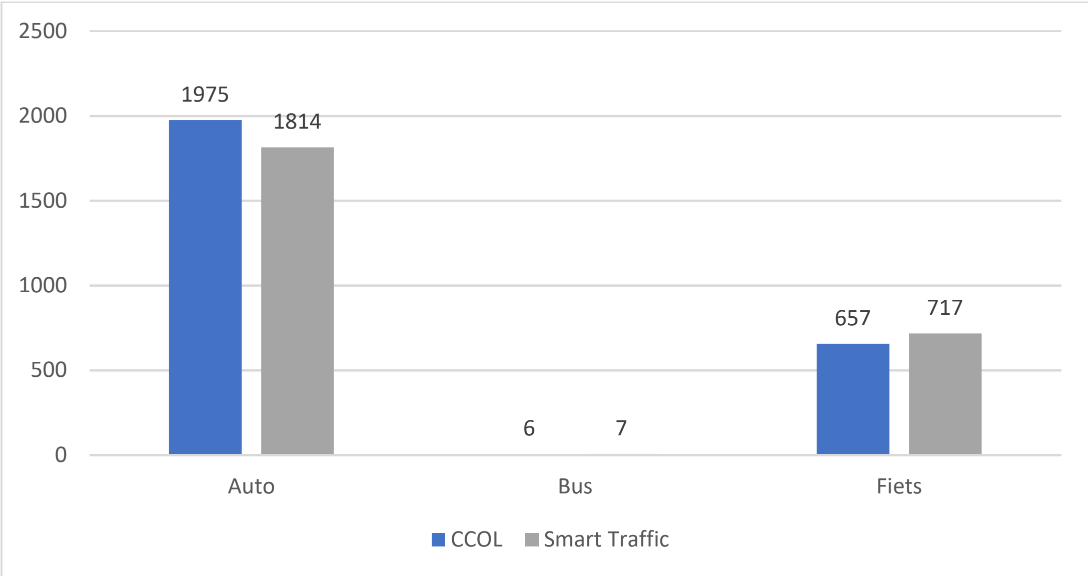

Figure 5 – Number of stops in the network

From simulation to the street

Not only has Smart Traffic been put through the test in a simulation environment, the software has since also been deployed on-site. Simulation results are obviously never exactly matching reality, so based on on-street analysis some configuration settings have been modified. One major advantage of cloud based control is that parameters can easily be adjusted without having to load new software on-site. Smart Traffic has to make certain assumptions while forecasting, e.g. detectors on single lane roads do not provide information about turn distributions. As the pool of data grows, there are fewer assumptions to be made. The system is running operational since September 2018.

Additional use cases

Smart Traffic makes it possible to deploy additional use cases including the prioritisation of specific vehicles and to inform (self-driving) vehicles about scheduled signal phases[4]. These additional Use Cases were also deployed in Helmond.

The use case prioritisation is intended for policy makers to prioritise based upon local policy. Examples of this use case are trucks receiving higher priority in the harbour or bicycles receiving higher priority in urban environments. In order to prioritise it is key that all vehicle movements around the intersection are correctly assigned to the correct modality. Prioritisation in Helmond was done by testing the system for emergency vehicles. When an emergency vehicle is approaching the intersection the movement is already forecast and scheduled. The disruption at the intersection will therefore be limited. This system was extensively tested in Helmond using a mobile test application simulating an emergency vehicle. Results show that queues are emptied before the vehicle arrives at the intersection.

The last but perhaps most important use case is to inform the vehicle about the status of the traffic light. Due to the predictive nature of Smart Traffic, it is possible to share a reliable (with high confidence values) time-to-green and time-to-red service with the vehicle. By using industry standards SPaT and MAP, it is straightforward to connect to this information for both regular and autonomous vehicles. Based upon the available data different use cases are possible, ranging from informing the driver via a smartphone app to informing a Cooperative Connected Automated Vehicle (CCAV) so it can adjust the speed in such way that no stopping is required. This service has been tested in Helmond with promising results. As soon as a green phase is planned, it is communicated via SpaT. Various Smartphone apps can display this information. In Helmond the Fortgång application Traffic Talker has been used for on-street analysis. Results show that the information is quickly shared and displayed on the phone without a visible delay. Figure 6 shows an example in Helmond.

Figure 6 – Time-to-red based on SPaT information

With the first results in Helmond a solid basis was built to tweak and tune Smart Traffic. Different use cases were successfully tested and have been deployed for production use. Further effort is needed to deploy this software on a wider scale and increase its impact.

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