Evaluation of Technical Systems of Systems Approach for Signal Control based on Real Field Data

Master's Thesis of Julio Vega Pérez

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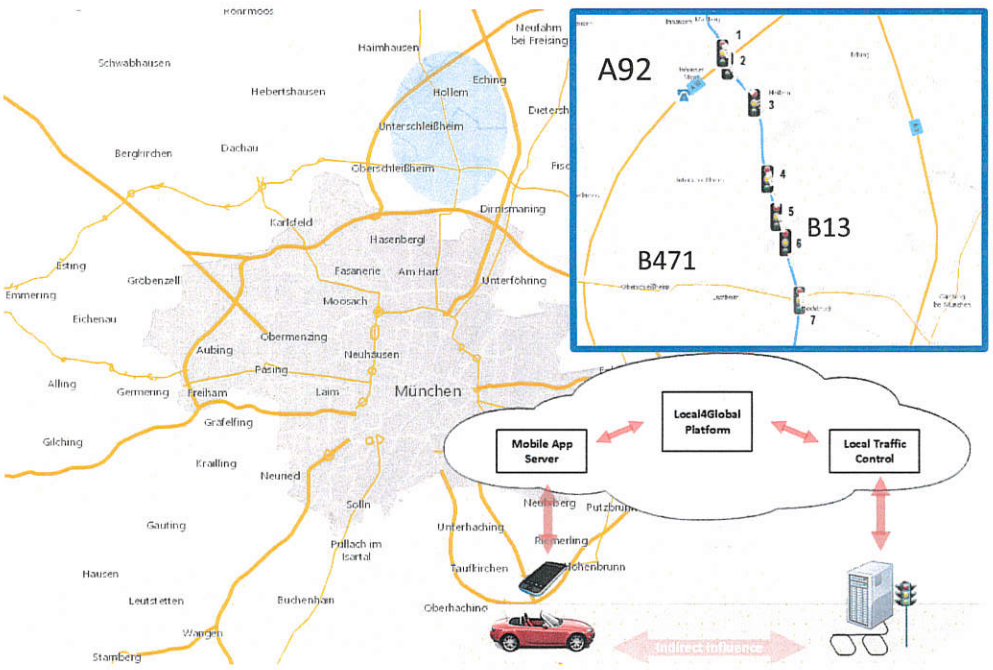
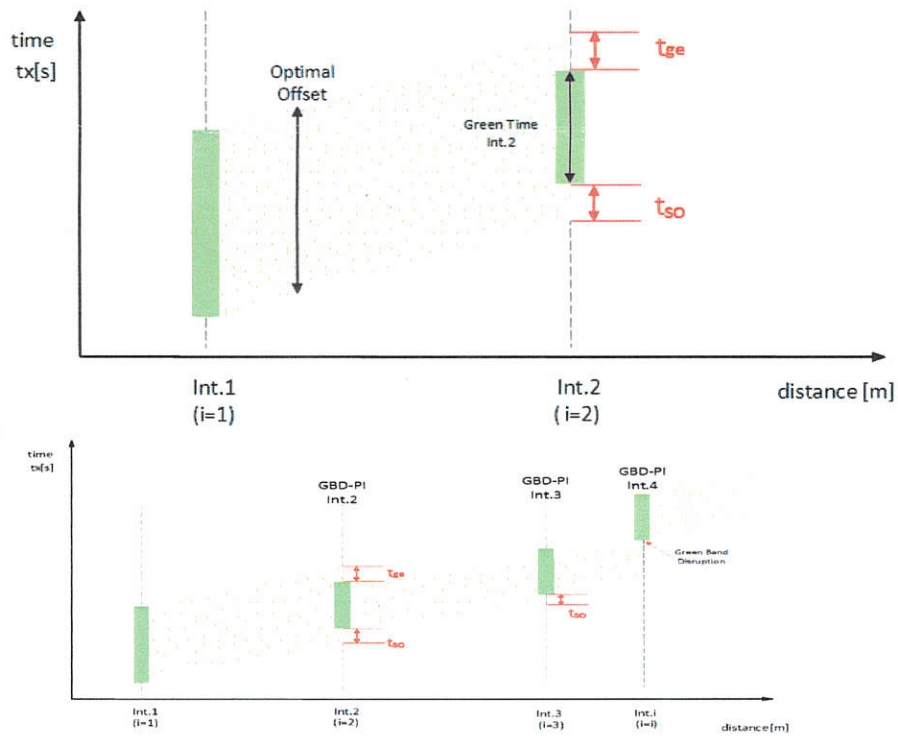
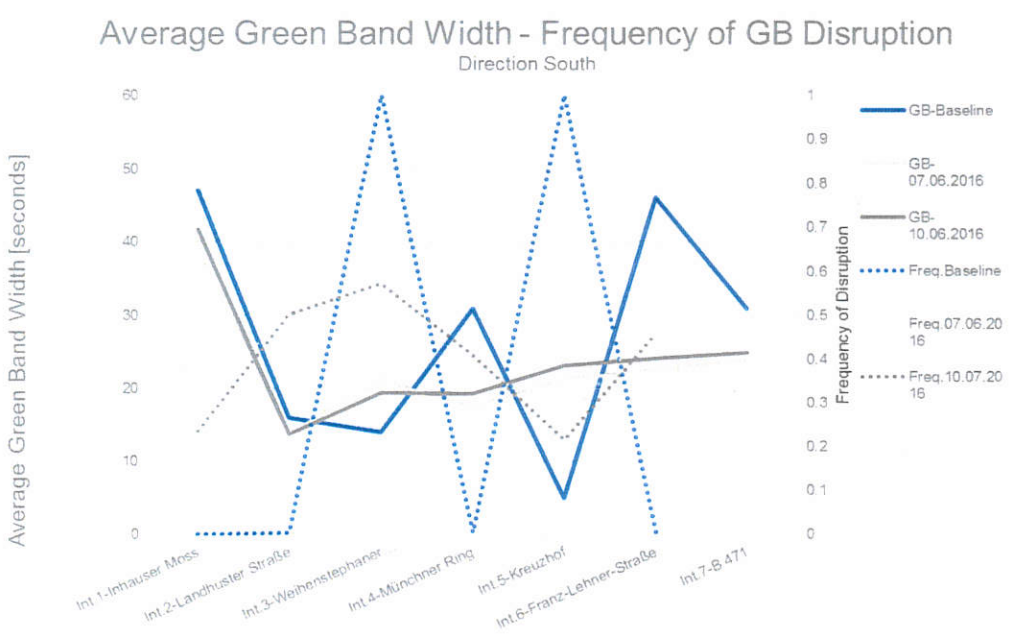


Map elaborated with data from Esri

Traffic lights coordination enhance transportation conditions since they reduce the number of vehicles stops at signalised intersections. Thereby decreasing negative externalities such as delays and pollution. Within the Local4Global (L4G) project, traffic light coordination and management of vehicles with recommended speed capabilities are optimised based on the concept of Technical Systems of Systems (TSoS). Thus, the L4G proposes a novel approach for traffic control based on intersections local conditions, thereby optimising the global performance creating traffic light coordination indirectly. The test bed for L4G is in the north of Munich on the B13 road, a track approx. 5 km long with seven signalised intersections represents a great opportunity for improvements.
The aim of this research is to evaluate in a closed control loop the performance of the L4G traffic control strategy. Nonetheless, the road authority has conditioned the implementation to be stepwise. First in an open loop control, and once the reliable performance is demonstrated, closing the control loop. Subsequently, this condition represents a technical gap, since the L4G needs feedback to optimise the traffic control continuously. Therefore, the gap is coped using an already established microscopic simulation environment in VISSIM to assess the performance of the innovative control approach.

In the German context, there are well-established and standardised methods for the evaluation of traffic coordination. The HBS[1] suggests the *Coordination Index*[2] (K) and alternatively the *Performance Index*[3] (PI) to evaluate the effectiveness of traffic coordination. The first method consists directly of counting the number of crosses without stops at signalised intersections for the coordinated (main) directions. Whereas, the second methodology considers waiting times and number of stops not only over the main coordinated directions but also on the secondary intersection approaches. Hence, both methods are adopted for the assessment of the L4G's performance. Moreover, a third evaluation method is suggested aiming to get further insights into the performance of the L4G control strategy.
The green band disruption (GBD)[4] approach is adopted since it represents a great potential for the evaluation of a traffic-responsive control strategy such as L4G. The GBD method consists of comparing the assigned green times of adjacent intersections assuming idealised conditions for platoon movements. Then, performance is indexed computing green band reductions at each intersection. The advantage of the GBD approach is that it does not require vehicle-related data but only traffic light information.





Traffic demand data was retrieved using OCIT[5] for the two first weeks of June 2016, excluding weekends. Using this traffic data in the VISSIM model, vehicle-related metrics allowed to compare the performance of both: currently applied control strategy versus L4G with the application of the methods mentioned above, K and PI. Additionally, signal plans suggested by the L4G and those applied by the current control strategy were utilised for the assessment of the GBD method.
The results indicate that the K method may be not sufficiently enough to assess the implementation of a novel control strategy such as L4G. The reason is that the ground philosophy of L4G is to create coordination in real time for those congested intersection approaches, which are not always the main directions.

[1] *Handbuch für die Bemesung von Straßenverkehrsanlagen*
[2] (FGSV 2015; S4-p. 53). FGSV. 2015. *Handbuch Für Die Bemessung von Straßenverkehrsanlagen (HBS).-. Ausgabe 2015*
[3] (FGSV 2015, S4-p. 79)
[4] Approach adopted from the work conducted by Rudolph & Hoyer (2014). Rudolph, Felix, and Robert Hoyer. 2014. "Performance Analysis of Coordinated Signalization Using Switching Time Data." In *10 Th, ITS European Congress*. Helsinki, Finland
[5] *Open Communication Interface for Road Traffic Control Systems*