INTELLIGENT MOBILITY APPLICATIONS FOR THE UK STRATEGIC ROAD NETWORK

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Background

Improvements in the capacity and reliability of road transportation systems have shown to impact directly on economic performance and quality of life for citizens. In the UK, there is limited scope to increase the capacity of strategic road networks by building more motorways. Hence, the focus now lies on enhancing intelligent mobility by using existing infrastructure more efficiently through the use of real-time data [1]. The aim of this project is to explore new ways to better use data provided by National Transport Information Service (NTIS) to understand and predict traffic congestion.

Data

UK motorways incorporate thousands of induction loops and other types of sensors at different sites throughout the road network. These sensors report different measurements for all parts of the road network to a centralized system managed by the NTIS. This data is made available publicly in the form of Daily Aggregated Traffic Data (DATD) publications and is used as the basis for this project. The DATD publications are published at the end of each day and contain multiple datasets pertaining to various measurements within the road network for that day. The data is stored in XML format and is available from the 1st January 2016 onwards. A subscriber system was built to receive the DATD publications from the NTIS servers. The system hosts a software that can request and download the publications. In addition, the system is able to extract the relevant data from the XML files and store it in a remote database.

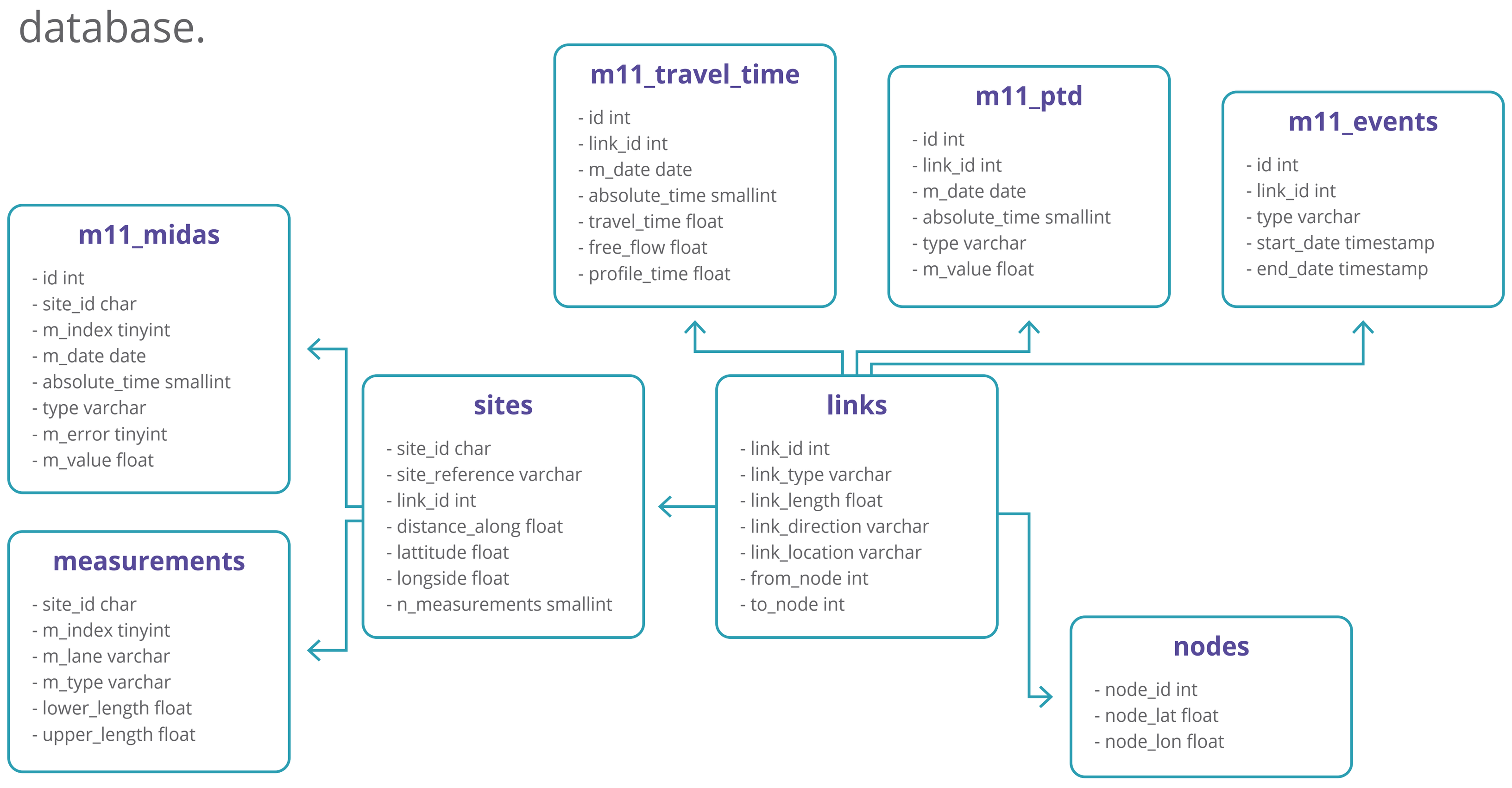


Figure 1. An illustration of the schema of the remote database used to store the needed data.

Congestion Duration Prediction

Thales developed an algorithm that predicts the duration of congestion events [2]. They are required to publish their predictions and are penalized if their accuracy is below 80%. The algorithm uses intelligent but simplistic assumptions; hence, it can be greatly improved by increasing its complexity.

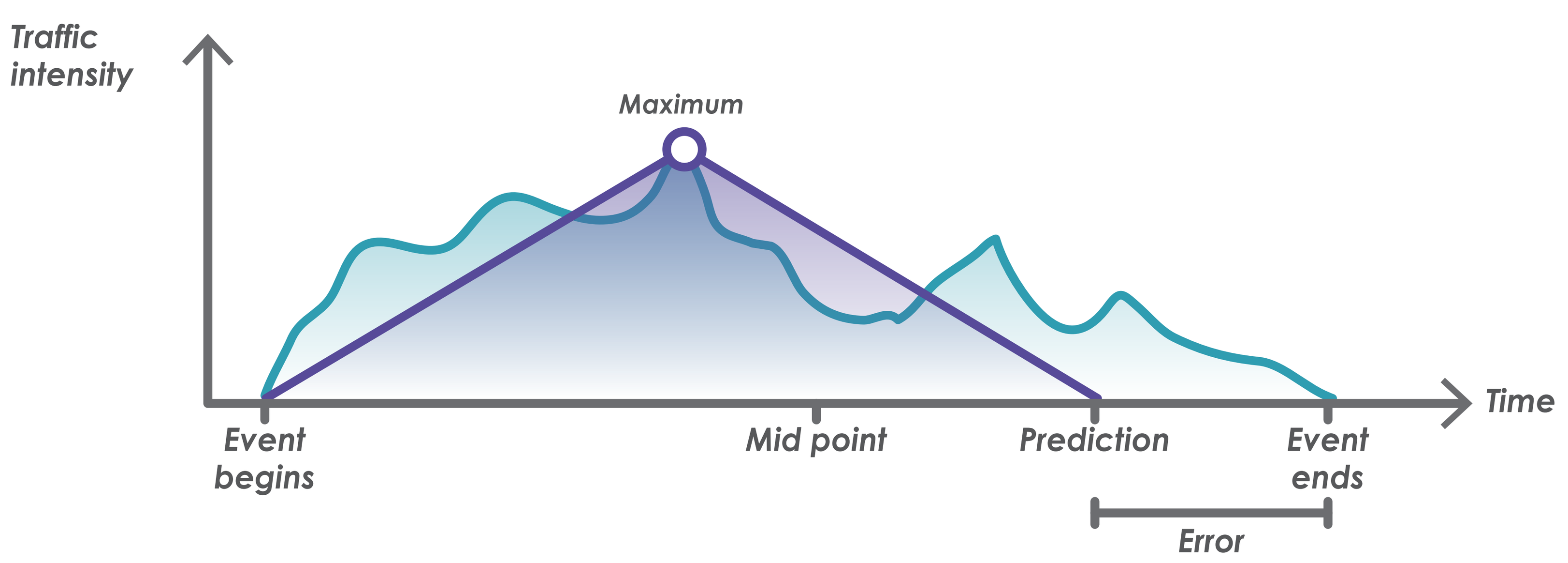


Figure 2. A diagram showing the congestion clearing algorithm developed by Thales.

Traffic Congestion Model

The most important equation in **traffic dynamics** is:

$$flow = speed * density \tag{1}$$

For each induction loop, the following graphs give important information about the dynamics of traffic.

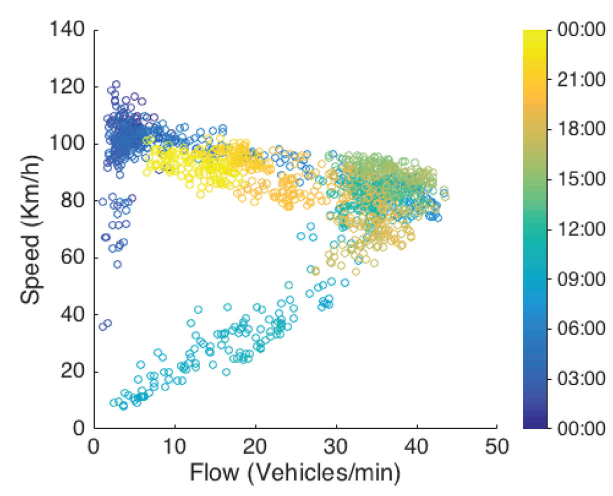


Figure 3. Speed vs. Flow

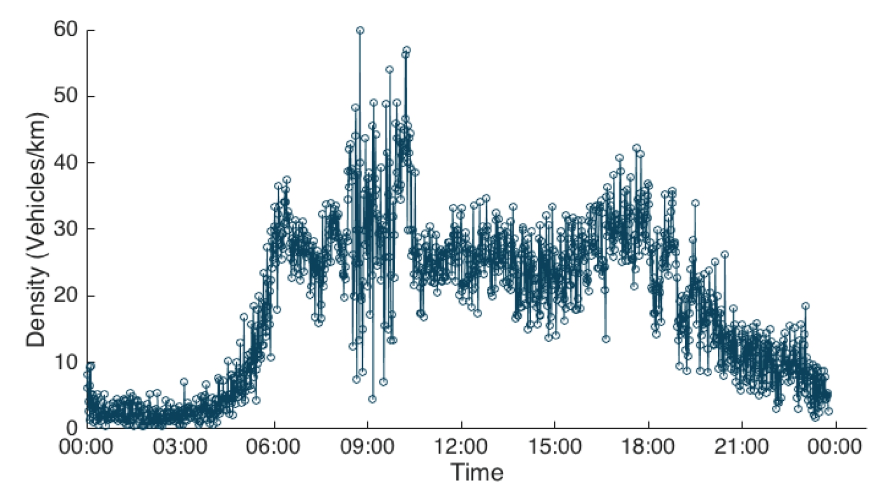


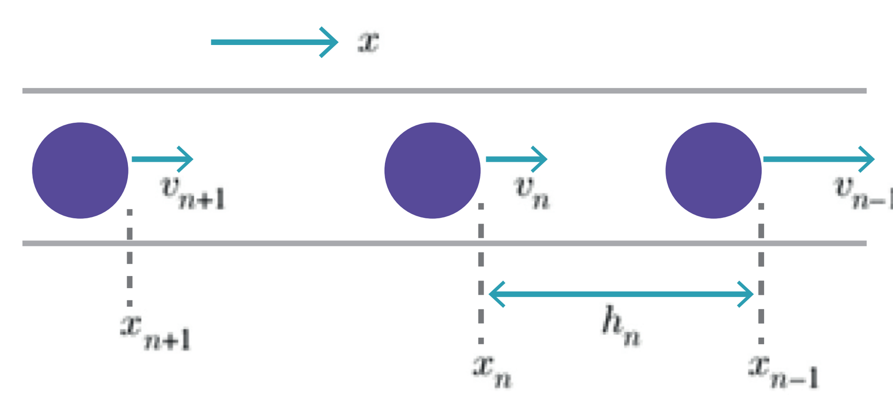
Figure 4. Density vs. Time

Macroscopic models, based on fluid dynamics, regard traffic as a fluid-like continuum. One macroscopic model that will be considered is the Lighthill, Whitham and Ricards model [3][4]:

$$\frac{\partial \rho}{\partial t}(x,t) + \frac{\partial f}{\partial x}(\rho,v) = 0 \tag{2}$$

$$v(\rho) = v_f\left(1 - \frac{\rho}{\rho_m}\right) - \frac{D}{\rho}\frac{\partial \rho}{\partial x} \tag{3}$$

Microscopic models consider individual vehicle dynamics. The "car-following" type of models will be examined in detail [5]. They are based on coupled differential equations for the trajectories of the vehicles, complemented with driver behavior profiles.



$$\dot{x}_n = v_n \tag{4}$$

$$\dot{v}_n = f\left(h_n, \dot{h}_n, v_n\right) \tag{5}$$

Figure 5. A graphical depiction of the car-following model.

The data analysis and modeling will be primarily focused on the M11 linking London and Cambridge and parts of the M6 near Preston.

Figure 6. Left: The M11 connecting London and Cambridge. Right: The M6 from junction 29 to junction 32 near Preston.

References

[1] Transport Systems Catapult. Intelligent mobility: Traveller needs & UK capability study, 2015.

[2] R. E. Wilson, B. P. Shrestha, and J. D. Lees-Miller. Prediction of time-to-clear: a report for the national traffic information service (ntis). Transportation Research Group, University of Southhampton, UK, 2013.

[3] M. J. Lighthill G. B. Whitham. On kinematic waves. ii. a theory of traffic flow on long crowded roads. In Proc. Roy. Soc. London A, volume 229, pages 317–345. The Royal Society, 1955.

[4] B. Piccoli, M. Garavello. Traffic Flow on Networks. AIMS of Applied Math. Vol. 1, 2006.

[5] R. E. Wilson. Mechanisms for spatio-temporal pattern formation in highway traffic models. Phil. Trans. R. Soc, pages 2017-2032. The Royal Society, 2008.