Day-to-day variation in level of trust in advanced traveller information and the impact of improved methods for estimating traffic states

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With advances in technological systems and communication infrastructure, advanced traveller information system (ATIS) is becoming widely popular. The information provided through ATIS can influence travel pattern and route choices of commuters, thus improve network performance. Travellers tend to change their route choices when travel time uncertainty increase on their preferred routes. The uncertainty in travel time is caused when the equilibrium is disturbed either by variation in traffic demand or change in a route capacity. The change of route capacity could be due to change in traffic controls, road works, severe weather condition or traffic incidents. Similarly, traffic demand for a route or network for a given departure time can also vary due to various possibilities such as weather, shopping events, festivals, exhibitions, sports, or due to variation in departure time of commuters. The traffic management authorities expect travellers to comply with the information provided, so as to reduce traffic congestion and improve system performance. The compliance of travellers to the information provided is highly dependent on the reliability of traveller information communicated through the ATIS. This study highlights the importance of real-time estimated traffic state for predicting traveller information and model dynamic level of trust in advanced traveller information when they observe that the traveller information is becoming more useful and reliable than their previous experience under fluctuating day-to-day traffic demand. Thus, this research is focused to address two main issues:

1: Traveller trust in the information versus their experience is dynamic, and depends on the perceived quality of information they received in the past.

2: To make commuters trust the information provided by ATIS (issue-1), it is important to have high quality methods for estimating traffic states.

We provide a method for improving the quality of traveller information (issue-2) in the context of traveller's dynamic trust (issue-1).

1. Dynamic trust level

Research studies conducted to combine the experience of commuters and traveller information assume the behaviour of commuters as non-dynamic. He and Liu (2012) proposed a model to capture the dynamics of day-to-day variation in route selection when the network is significantly disrupted for a longer period of time. Cho and Hwang (2005) developed a model that combines users' behaviour with the predicted information provided by advanced traveller system (ATIS) and traveller information provided by ATIS is based only on flows from previous days. Duong and Hazelton (2001) proposed a Markov process based model for day-to-day traffic assignment that incorporates the effect of pre-trip information in route choice of travellers. Jha *et al.* (1998) proposed a framework using Baysian approach to update the perception of travellers based on information provided by ATIS and experienced travel time. Ben-Akiva *et al.* (1991) proposed a convex combination approach to model the perception update. If τ_e is experienced travel time and τ_p is predicted travel time for current journey, the updated perception about expected travel time is given by Ben–Akiva *et al.* (1991):

$$\tau_u=\tau_e\alpha+\tau_p(1\text{-}\alpha) \qquad (1)$$

Where α is the parameter that reflects whether $\tau_p$is trusted more or τ_e is more reliable and assumed to be constant. In conclusion, significant amount of studies have been conducted to integrate the effect of traveller information with experienced travel time to update the perception of commuters about their route choice but assumption on experienced travel time and traveller information provided by the ATIS are abstract. Furthermore, the perception update process of commuters does not consider dynamics in level of trust in traveller information and assumes the parameter reflecting this behaviour as constant. If travellers find the traveller information is becoming more accurate and reliable compared to their experienced travel time they will more trust the information, thus the parameter reflecting choice between the information and own experience becomes dynamic and a function of reliability of experienced and predicted travel time. We propose the following changes in equation (1):

$$\tau_{u,d} = \tau_{e,d-1}\alpha(\tau_{e,d-1},\tau_{p,d-1}) + \tau_{p,d}(1-\alpha(\tau_{e,d-1},\tau_{p,d-1})) \qquad (2)$$

Where $d$is the current day and in equation (2) we convert α from constant to a dynamic function of reliability of traveller's experience time and quality of traveller information provided.

2. Traffic state estimation

Existing literature in the field of day-to-day route-choice behaviour modelling and traveller information does not address the issue of reliability of traveller information. When the traffic demand is varying day-to-day for a given departure time, a commuter will experience a different travel time on the same route compared to the past experience. Similarly, if the traveller information communicated to the travellers using ATIS does not model the variations in traffic demand or network capacity, the travel time experienced by commuters can be significantly different from the one predicted by ATIS, which may cause travellers to doubt the information and ultimately start ignoring it. The main motivation of this paper is to improve reliability of traveller information using real-time estimated traffic state and thus model dynamic behaviour of commuter in response to more reliable traveller information than their past experience.

Real-time traffic state estimation has been an active field of research for many years. With the development of new technologies and the improvement in existing techniques for acquiring real-time traffic data, more emphasis is being given to proper utilization of such data, to obtain a more accurate and widespread picture of the state of a network. However, there are limitations in the data directly obtained from traffic sensors. Firstly, such data does not include all the required parameters for devising traffic management strategies in real-time and does not portray a complete picture of the traffic state across a network. Another problem with obtaining real-time traffic data is that it requires a good communication infrastructure. On the other hand, the prediction of traffic state using only traffic flow models based on long-term historic information might contain significant error in prediction, especially when actual traffic conditions depart from their historical trend due to external factors. To obtain complete traffic data for the whole network, traffic flow models along with measurements from sensors are used for better estimation with less uncertainty in the final estimate of traffic state compared to prediction or measurement alone. Thus, 'real-time traffic state estimation' refers to estimation of traffic flow variables (traffic flow, density) for a segment of road or network, with an adequate time and space resolution based on limited available measurements from traffic sensors (Wang, Papageorgiou and Messmer 2008).

3. Combining dynamic trust level and traffic state estimation

In this research study, we predict travel time for the ATIS based on real-time estimated traffic state. A within day dynamic model uses the cell transmission model (CTM) proposed by Daganzo (1995) and Szeto *et al.* (2009) to predict the traffic flow in a hypothetical urban network. Extended Kalman Filter (EKF) approach proposed by Wang and Papageorgiou (2005) is used to combine prediction of traffic flow from CTM and real-time measurements from the sensors to obtain estimated traffic state. A day to day model provides time varying demand to within day dynamic model and stores experienced travel time of commuters to utilize them on current day *d.* The day-to-day model also estimates dynamic level of trust in traveller information by comparing the actual travel time for a given journey with the traveller information. Commuter's past experience and the traveller information is combined to obtain perception update using equation (2) with dynamic α as a function of varying reliability of experienced travel time and the traveller information under day-to-day fluctuating traffic demand. The conceptual framework of proposed research methodology is further elaborated in figure 1 (on next page).

The proposed framework is applied to a diverging urban network for numerical illustration. The simulation results show that with day-to-day varying traffic demand, traveller information using estimated traffic state from CTM-EKF model was more accurate for a given day than commuters past experience. Thus, commuters level of trust in traveller information provided by the ATIS increases and as a result network performance is improved when commuters avoid taking the congested route and shift to the less congested route with lesser travel time.

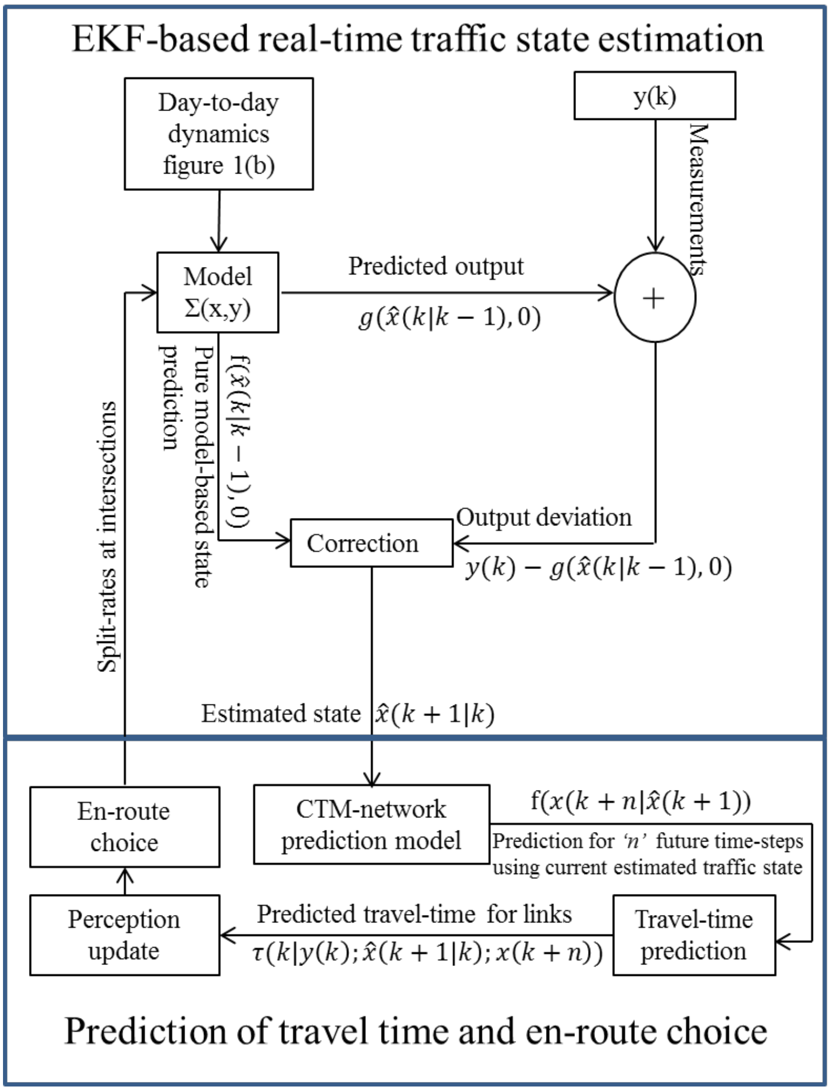

Figure 1(a). Framework of within day modelling for real-time traffic estimation and prediction of travel time for ATIS

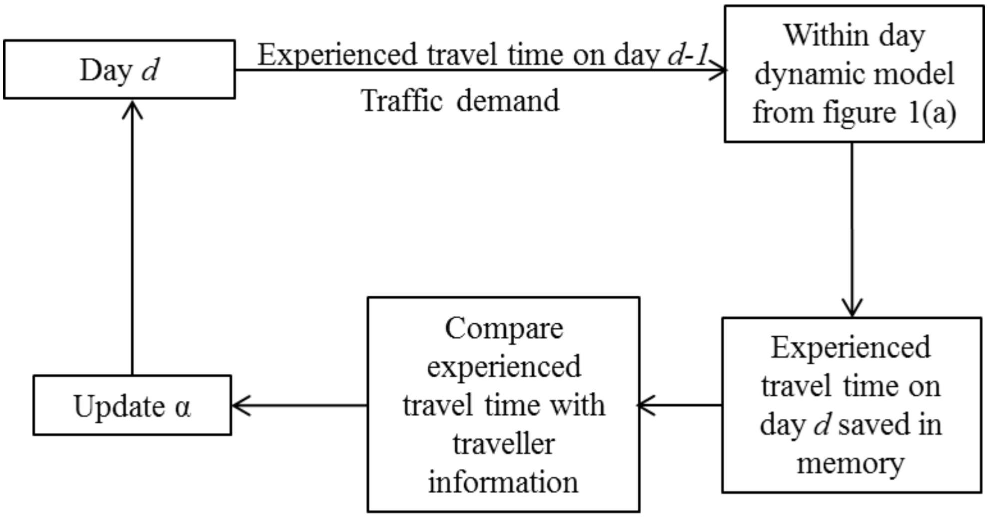

Figure 1(b). Process flow for day-to-day dynamics and updating α