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Incident management and network performance

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Abstract

This paper describes an investigation into the scope for reducing trip time variability associated with incidents (e.g. accidents), through better incident management. The investigation involved using micro-simulation (S-Paramics) to model incident detection and response in a part of the Auckland (New Zealand) network, which includes a motorway and adjacent parallel arterial roads. The effect of blockages on the motorway or an adjacent arterial road, with and without mitigation (e.g. modifying the SCATS arterial road signal coordination plan, using variable message signing and allowing motorway traffic to use the hard-shoulder), were assessed. It was found that the reductions in the variability of trip times, as a result of implementing mitigation options, were much larger than the reductions in mean trip times.

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Keywords: incident management; micro-simulation; S-Paramics; SCATS; trip time variation

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1. Introduction

The economies in developed countries depend heavily on their transport systems, and that dependence has increased with the adoption of 'just-in-time' production methods, the success of which depends upon predictable trip times. This is especially true for freight movements, as evidenced by programmes such as the European Commission's Marco Polo programme, aimed at easing road congestion, thereby improving the efficiency and reliability of freight transport.

Concern about the travel time variability has been growing for some time, with a study for the UK Department of Transport (SACTRA, 1999) concluding that ignoring the effect of travel time variability led to the economic benefits

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of trunk road projects being under-estimated by between 5% and 50%. A subsequent UK study (Eddington, 2006) also stressed the importance of accounting for the reliability of travel time.

Traffic congestion is commonly divided into ‘recurring’ congestion, which occurs when there is regularly not enough capacity in the transportation system to meet the demand (e.g. during peak-hour periods of the day), and ‘non-recurring’ congestion, which occurs when there is a temporary and ‘unexpected’ reduction in capacity due to incidents (e.g. crashes, vehicle break-downs). Both types of congestion are important, with incidents being estimated to be responsible for about half of the congestion on US freeways (US DoT, 2000; Schrank and Lomax, 2009).

It seems likely that variability associated with recurring congestion will be allowed for in trip planning, with the occasional instances of unexpectedly high delay being largely associated with non-recurring congestion. It therefore seems likely that reducing non-recurring congestion will have a greater effect on the perception of reliability than reducing recurrent congestion.

Successful management of incidents on road networks involves both efficient detection of incidents (including identifying their location and nature, preferably by automated means) and identifying suitable treatment options, both in terms of removing or fixing the cause of the incident and managing vehicle flows during and after the incident.

Williams and Guin (2007) reviewed the various algorithms, devised since the 1970s (e.g. Payne, 1975), for detecting incidents on traffic networks. While early algorithms were largely based on simple speed or occupancy comparisons and classical traffic flow theory, more recently complex techniques have been tried, such as neural networks (e.g. Srinivasan et al., 2004), fuzzy logic (e.g. Yaguang and Anke, 2006) and wavelet transformations (e.g. Samant and Adeli, 2000). Williams and Guin also report that a survey of 32 traffic management centres across the USA revealed a lot of concern with the performance of existing automatic incident detection algorithms, with 81% stating that even if reliable and accurate algorithms were available in the future, they would continue to employ other methods of incident detection (e.g. mobile phone calls or operator visual detection).

Incidents are commonly of relatively short duration. While equilibrium methods can be used for modelling long-duration road closures (Dalziell and Nicholson, 2001), it has been shown that microsimulation is much more appropriate for short-duration closures (Berdica et al., 2003). There have subsequently been many studies that have used simulation to investigate the effect of short-term incidents. For instance, Hadi et al. (2013) used macroscopic and microscopic simulation modelling (FREEVAL and CORSIM respectively) to estimate the delays of previously observed incidents.

Kamga et al. (2011) looked at how network performance is affected during an incident, by simulating incidents in a dynamic traffic assignment model. A case study was performed on part of the greater Chicago network, allowing for alternative routes for origin-destination pairs. A base case scenario was generated to depict operational characteristics of the network under normal traffic flow conditions. Then, an incident was simulated for two scenarios:

- firstly, where all drivers were assumed to have no information on the incident, with all drivers being assumed to follow their current (or ‘no incident’) paths;
- secondly, where all drivers are assumed to have perfect information of the incident conditions, with traffic being reassigned to the network using a dynamic user equilibrium method.

This approach is consistent with that proposed by Nicholson et al. (2003), who proposed considering the cases of zero and perfect information, to get upper and lower bound estimates of the impact of disruption. In practice, a real-world scenario will be somewhere between these two extremes, depending on the level of traveller information available to motorists and the propensity of motorists to ignore such information.

The results from Kamga et al. (2011) confirmed that an effective traveller information system has the potential to ease the impacts of incident conditions network-wide. However the results also suggested that incidents have a different impact on different origin-destination pairs, with the use of traveller information to help reassign traffic giving an advantage to motorists travelling between some origin-destination pairs and a disadvantage to motorists travelling between other origin-destination pairs.

The focus of the study reported here is identifying effective and efficient treatments. Treatment options can be considered to fall into two categories, advanced traffic management systems (ATMS) and advanced traveller information systems (ATIS). ATMS options include:

- dynamic traffic signal control, with signal timings being adjusted as traffic flow patterns change;