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An efficient solution to toll choices involving multiple toll booths and/or multiple tolling structures

Title of the paper

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BIOGRAPHICAL SUMMARY FOR MAIN AUTHOR (100 words mini-CV)

Keith Long is a highly skilled traffic modeller whose services have been keenly sought by government bodies and the private sector especially for major transport infrastructure projects. He has special interests in toll road demand forecasting and strategic urban transport modelling.

AUDIOVISUAL SUPPORT NEEDED

(A PC with Office XP, a projector, and a microphone will be provided. Please mention any other needs.)

None

ABSTRACT (500 words)

This paper presents an efficient solution to the problem of modelling toll choices involving ***multiple toll booths and/or multiple tolling structures*** (such as toll caps, toll discounts, distance-based tolls, boarding tolls, exit tolls and so on).

As toll choices involving multiple toll booths with multiple tolling structures become more common, modellers have begun moving away from traditional Toll Delay Penalty (TDP) approaches to the more suitable Behavioural Route Choice (BRC or logit) approaches. However, traditional BRC models encounter convergence and runtime issues because of the sheer number of toll segments (ie combinations of toll booths in a single trip) that need to be evaluated.

For example, the recent opening of Sydney's Westlink M7 Motorway (a distance-based tollroad with a toll cap) has increased the number of Sydney's toll booths from 19 to 77, and the number of viable toll segments from around 34 to around 335. The imminent opening of Sydney's Lane Cove Tunnel, together with the proposed M4 East and F3-M2 will exacerbate the issue.

The solution adds ***dummy*** zones to a conventional road network. A dummy zone straddles each link containing a toll booth (real or virtual), so that each dummy zone represents that particular toll booth. The total number of zones is therefore the number of zones in the ***conventional*** road network ***plus*** the number of ***dummy*** zones. A modified road assignment procedure allows attributes between each origin-destination pair (such as travel times, free-flow times and stop-start times) to be saved into a ***matrix***. The solution assesses the tolled route options (whether using a single toll booth, two toll booths, three or more tollbooths etc) against the free alternative, by extracting the relevant values for that attribute from the matrix. The process loops around all possible tolled route options ***on the fly*** – a number of check tests improves the efficiency. For each origin-destination pair of each market segment, the solution identifies the number of valid tolled routes, and then proceeds to calculate, for each route, the generalised times and utilities.

These utilities are then input into a toll choice (BRC or logit) model, which calculates the probability of using a particular tolled route. The current Sydney model uses a nested logit, with the upper level choice being between the utility of the free alternative and the ***best*** tolled utility. Having established the proportion of tolled trips for each origin-destination pair and market segment, these tolled trips are then allocated between the valid tolled utilities using a typical multinomial logit function.

Finally, the tolled origin-destination trips are ***unpacked*** into their component legs. The total demand matrix, being the untolled matrix plus the tolled leg matrix is then assigned to the conventional road network with all toll links banned. The procedure continues interatively (using a successive average process) with updated travel times input to the toll choice model, until the predicted toll road traffic converges. One total demand matrix, plus a single class equilibrium assignment, are all that are required to ensure each trip leg is correctly assigned.

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