Dynamic Capacity Allocation

Iraklis Stamos *

Hellenic Institute of Transport,

Centre for Research and Technology Hellas, Thessaloniki, Greece

Evangelos Mitsakis

Hellenic Institute of Transport,

Centre for Research and Technology Hellas, Thessaloniki, Greece

***** Email: stamos@certh.gr

1 Introduction

In general, transport supply under non-congested and incident-free traffic conditions is expressed as the capacity provided by transportation infrastructures. Whereas this capacity is in principle fixed over a road network (in terms of served traffic directions), this paper introduces the concept of Dynamic Capacity Allocation, in an effort to maximize the utilization of the existing capacity. The basic idea behind the Dynamic Capacity Allocation problem is related to the time varying use of the existing capacity of network links, subject to variable demand (temporally and spatially). The time varying use of the existing capacity may be interpreted as a partial or full reversal of links' directions or any other modification of the network's components towards variable use of the existing capacity. The concept of Dynamic Capacity Allocation is mainly differentiated from any dynamic traffic management strategy since it concerns a full scale application in a given network (both in time and space, i.e. it is constantly applied, evaluated and re-applied) and is triggered by any transport demand change within an interval rather than a duration confined incident calling for traffic management. This paper offers preliminary insights on the proposed mathematical formulation of the Dynamic Capacity Allocation problem and discusses the relation and contribution to the Dynamic Traffic Assignment problem together with considerations related to the problem's constraints and solution methods.

2 Literature Review

The idea of dynamically allocating the capacity of links in a transportation network based on the prevailing and expected travel demand has not been studied yet in the literature, at least to our knowledge.

Efforts so far concerning changing the capacity of links in general were directed towards the use of lane reversal techniques in order to balance bidirectional travel demand

[1,2]. These were only studied at a planning level. This use of capacity allocation is rather limited, as it generally refers to a local change, and static, as the capacity allocation is not time-varying but fixed over time. In the last decades, dynamic capacity allocation is studied for emergency management and evacuation and is used as a tool in various studies and models in order to maximize network traffic throughput during events [3,4,5]. At the same time, various evacuation software packages have been developed incorporating the idea of reversing the traffic direction of inbound lanes in order to increase capacity for the outbound traffic [6,7].

3 Description of the Dynamic Capacity Allocation concept

The question introduced here is how to dynamically allocate capacity in a network in order to better manage the supply-demand interaction in a network and improve overall traffic conditions. In this concept, we expand the use of dynamic capacity allocation through lane reversal, formerly used only for emergency situations, to a general use. We purport that variable travel demand can be variably served during the day so as to minimize overall travel time in the network. In addition, we suggest that when allocating capacity for a given travel demand at a time interval t, the travel demand for subsequent intervals t_1 to t_n should be also taken into consideration. We assume that travel demand can be known prior to the solution of the Dynamic Capacity Allocation problem or can be treated in real-time parallel to the solution of the problem.

Mathematically expressed, the Dynamic Capacity Allocation problem is an optimization problem, whose objective can vary, based on the application, for example minimize overall travel time, maximize utilized capacity, or minimize environmental impacts. The formulation of the problem relies on the Dynamic Traffic Assignment problem formulation with the addition of the capacity allocation parameter. The problem is solved using a dynamic system optimal computational process at macroscopic level and the optimization process is terminated when the convergence criteria are met (i.e. when any further capacity change, cannot minimize/maximize the objective).

4 Conclusions-Reference to the full study

In the present study we introduce the concept of Dynamic Capacity Allocation as a mean to optimize the utilization of the capacity provided by transport networks. In this concept, capacity is treated as the decisive parameter that optimizes traffic flow conditions through its variant allocation.

Concerning a realistic implementation of a Dynamic Capacity Allocation strategy, this can indeed raise a series of safety and applicability issues. Certain policy and

implementation constraints could be used as input in the solution of the problem (e.g. the solution is not allowed to change the direction of all lanes in a given road segment, lane reversals and capacity changes are only allowed in predefined links) However, in this paper we generally assume that these constraints are given and irrelevant to the formulation of the problem. The scope of the Dynamic Capacity Allocation concept concerning its realistic implementation lies mainly in the future, where automated transportation systems could indeed allow a safe full scale practice that could in a way manage traffic in contrast to nowadays road tolls.

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