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Dr. Ali Gul Qureshi is an associate professor in the Department of Urban Management at Kyoto University, Japan. His basic education is in civil engineering with specializations in transportation engineering, logistics and operations research. His research interests are related with exact and heuristics optimization of different variants of vehicle routing and facility location problems, their integration in different frameworks such as multi-agent systems, and their application in evaluation of city logistics measures. His recent research also relates with humanitarian logistics after disasters. Course Taught by Dr. Ali Gul Qureshi is Sustainable Urban Freight Transport.

VEHICLE ROUTING PROBLEM IN CITY LOGISTICS

***Abstract*:** The main aim of urban planning systems is to create a sustainable urban environment. It is usually achieved by dividing the city in various land use areas and by setting certain restrictions on developments types in each of them. For example, residential areas are usually assigned further away from heavy industry zones. The interaction between land use planning and the passenger transportation has received a lot of attention in the research and practice. However, the interaction between land use planning and the design of urban logistics systems has only been restricted to the location of warehouses and distribution centers (*1, 2*). The size, location and density of such freight facilities along with the land use pattern will affect the freight systems (such as central vs. satellite distribution) and the type of vehicles used for transportation (i.e. large and/or small trucks) (*3*). It has been found that the industrial land use developments often lead to freight shipment traffic increment, impacting the neighboring transportation network (*4*). As the last-mile delivery in the urban logistics system is mostly carried out using trucks and vans, it contributes heavily in the typical traffic-related problems such as congestion, idling and environmental emissions (*5*) as well as increase the probability of freight vehicles-related crashes (*6*). City logistics aims at the mitigation of these ill-effects considering both public and private costs (*7*) with the introduction of various policies and schemes such as cooperative delivery systems (*8, 9*), and road pricing of urban freight (*10*). Route optimization is also one of the city logistics schemes, which can also be used as a tool for evaluating many earlier-mentioned city logistics initiatives.

Since its inception in 1959 (*11*), the Vehicle Routing Problem (VRP) has attracted many researchers and a number of variants have found their way in the literature based on inclusion of different practical constraints. Addition of the time windows constraints leads to the vehicle routing problem with time windows (VRPTW) (*12*). Whether or not a delayed service with penalties is allowed, VRPTW further extends to its soft time windows (*13, 14*) and hard time windows variants (*15*), respectively. The Vehicle Routing and scheduling Problem with Soft Time Windows (VRPSTW) can be used for optimized and efficient logistics operations (*16*). It consists of finding a set of minimum cost routes (for delivery vehicles) to cover demands (weights to be picked up or delivered) of all customers within their specified time windows $[a_i, b_i]$. If a vehicle arrives earlier it has to wait (without associated cost) until the start of time windows (a_i); whereas, the delivery after b_i is only allowed at some penalty cost. Minimization of the operation cost is used as the main objective in the VRPSTW, irrespective of the footprints of resulting vehicle routes in the urban areas. The environmental benefits are mostly obtained as a by-product based on the minimization of the traveled distance. In earlier studies, it has been found that even a simple optimization may result in better overall cost and less environmental impacts as compared to the actual operation of the urban freight vehicles (*17*). The behavior of freight carriers is often modelled by the VRPSTW with the main objective of minimization of total operation cost. On the other hand, better living environment (less traffic, less emissions, better road safety) is the main concern for the other stakeholders of city logistics (such as administrators and residents) (*18*). This paper presents some of the variants of VRPTW researched by the authors in the field of city logistics, which also include a range of rich VRPTWs aimed to reduce environmental footprint of the freight deliveries in residential areas, and improving the safety and environmental concerns around some of the sensitive urban facilities.