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Development of hub and spoke model for improving operational efficiency of bus transit network of Bangalore city

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ABSTRACT

In a large city, operating a bus transit service on a route network based on destination-oriented or point-to-point approach, which considers all possible routes with the node set, is cumbersome and impractical. Alternatively, a Hub and Spoke network, which combine the destination-oriented and direction-oriented approaches, could be a more efficient choice. However, this model has only been applied to airline networks, whose influencing factors and variables could widely differ from those of an urban transit network. This paper proposes an approach to develop a hub and spoke network for an urban bus transit service in the Indian context. The proposed methodology consists of finding optimal locations for potential hubs, allocating non-hub nodes to hub nodes, and generating inter-hub and intra-hub routes and the frequencies of the bus service in those routes. For the case study, the proposed model is applied on the bus service operated by Bangalore Metropolitan Transport Corporation (BMTC) in Bangalore City, India. The results suggest noticeable savings in operator cost and CO_2emissions compared with the existing point-to-point operational approach. This is significant considering that most of the urban bus transport corporations in India are currently under losses.

1. Introduction

Public transport system offers an efficient way of accommodating the ever-increasing travel demands of the urban areas. It also plays an indispensible role in dealing with the social, economic and environmental problems created by the rapid urbanization, especially in the developing world. It also plays an important role in reducing urban traffic congestion and CO_2 emissions. For historical and economic reasons, different modes of public transport are predominant in different parts of the world. In most Indian cities, buses occupy a major share of the public transport.The public transport route network design problem involves determination of a set of routes and associated frequencies, subject to a set of feasibility constraints, to achieve the desired objectives. The general objective is to reduce the overall system costs including both user and operator costs. More specific objectives may include reducing the overall system cost and maximizing the social welfare (Bellei et al., 2002; Spasovic et al., 1994; Chang and Schonfeld 1991). User costs are generally measured by the total time incurred to the users, which consists of waiting time, in-vehicle time, transfer time etc. Operator costs depend on the fleet size, vehicle kilometer and vehicle operation hours required for a route configuration. And feasibility constraints are based on the maximum route length, maximum and minimum load factor, fleet size, maximum allowable headway, available resources including capital and operating costs etc.

In the recent past, most of the urban bus transport companies in India have reported losses, and improving their operational efficiency could be one of the ways to tackle it. Also, whenever there is an increase in the operational costs, say fuel price increases, they resort to increasing the bus fare. As this further increases the burden on the commuters, the efficacy of such a measure is doubtful. In such a scenario, a re-structuring of the bus network could help alleviate that burden on the commuters.

Population of Bangalore has increased at a much faster rate from 4.2 to 9.6 million during the period 1991–2011. Bangalore Metropolitan Transport Corporation (BMTC) was the sole provider of public transport services till Bangalore Metro Rail (BMR) started its operation in October 2011 with an initial route length of 7 km (other lines are still under construction). BMTC is currently

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Fig. 1. TTMC buildings serving both transport services and commercial establishments.

operating 908 routes by utilizing 6056 buses to satisfy the demand of Bangalore urban and rural area.

Recently, BMTC has built many Traffic and Transit Management Centers (TTMCs) spread over different parts of the city (Fig. 1). Objectives of these TTMCs are to provide an integrated transport facility with adequate amenities to cater to the requirements of user, to encourage use of public transport and provide first/last mile connectivity through provision of park and ride facilities, facility for seamless across the platform transfer, generating revenue through commercial establishments, etc.

It can be seen from Fig. 2 that TTMCs are spread out across the Bangalore city and cover most parts of it. Some of these TTMCs are still under construction while others are already operational. Present bus route network of BMTC is destination-oriented and is developed based on rules of thumb. Due to this, bunching of buses and irregular distribution of headways on the stops of the routes are a common feature of BMTC services today. Also, while BMTC has made profit from its operations in the past, it is fast diminishing now with every passing year. Table 1 shows the increasing difference in earnings and cost of operations per kilometers of BMTC in last 6 financial years.

It seems that BMTC has not been able to fully exploit the power of its TTMC infrastructure to improve their operational efficiency and thus reduce their operating cost. An attempt is made in this paper to leverage this infrastructure to its full efficiency and re-design bus transit route network for Bangalore city, while still

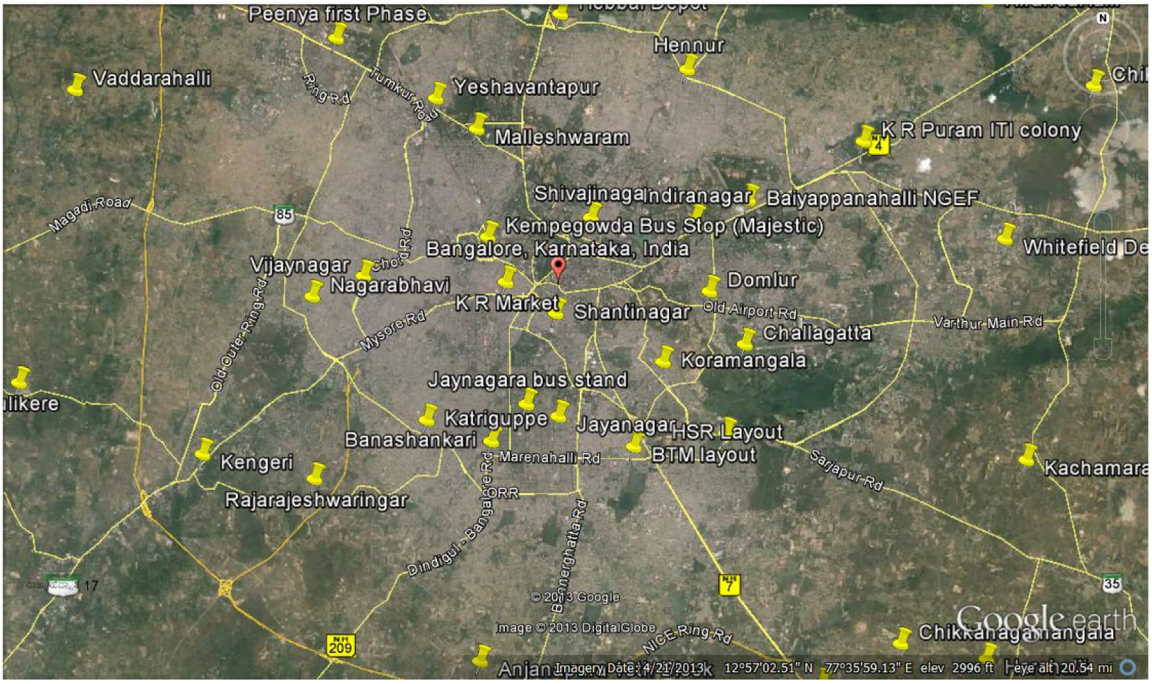

Fig. 2. Location of TTMCs across Bangalore city (shown as yellow tags). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)