Game Theoretic Models for Competition in Public Transit Services

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Keywords : public transit, competition, potential games

Abstract

Metropolitan areas have accounted for the majority of increases in population and economic growth in recent decades. China's phenomenal economic development has been fuelled by growth in the major cities, many of which has over 5 million in population. Metropolitan areas account for over half of the population, and a significant majority of the GDP, of the United States. As the geographical size and population of major metropolitan areas have increased, much economic activity remain focussed in the central business districts of the metropolises, thus the average travel distances for work have not decreased as expected. The average commuting distance for the London boroughs is over 10 kilometres. The need to travel by the populace has placed significant burden on the transport systems of metropolitan areas, leading to increased traffic congestion and attendant safety and environmental concerns.

Development of transport infrastructure and public transit services have not kept apace with the swell and sprawl of metropolitan areas, with serious congestion occurring in central business districts and insufficient coverage in peripheral areas. In metropolises where public transit services are provided by private firms in a relatively free market, operators tend to focus on high-profit routes and outlying smaller communities are under-served. In Hong Kong, the already congested Central business district is often jammed with half-empty double-decker buses from all the bus operators, while bus services to satellite communities in the New Territories are very infrequent and expensive.

In this paper, we discuss some game-theoretic models that can be used to investigate the competitive situation when several service providers offer public transit services, and study the impact on the total set of services offered to the public and the resultant level of ridership of the system. The competition among the operators can be modelled by a class of games called potential games. We discuss mathematical programmes that can be used to find the Nash equilibria for these games. By examining the equilibria solutions, we can examine the relative merits and tradeoffs for different structures of the transit networks, and the interplay between the services offered and the overall ridership of the system.

We hope that our modelling and analysis may provide some insight on the types and bundling of routes being offered by operators, and the locations for transportation interchanges and hubs.