Statistical Analysis and Modeling of the Korean Urban Bus Network

Inho Hong[1], and Woo-Sung Jung[1,2]

[1] Dept. of Physics, POSTECH 77 Cheongam-Ro, Pohang, Gyeongbuk, 790-784 Korea

[2] Dept. of Industrial and Management Engineering, POSTECH 77 Cheongam-Ro, Pohang, Gyeongbuk, 790-784 Korea

E-mail: [1]ihong@postech.ac.kr, {[2]wsjung@postech.ac.kr}

Abstract

The importance of understanding urban systems is increasing with fast urbanization over the world. A variety of urban systems such as transportations [1], and infrastructures [2] have been investigated as complex systems. In this research, the urban bus system, which is the main public transportation in Korea, is studied for understanding the formation of urban transportations. The analysis is carried out for two types of networks: bus stop network and town network. In the bus stop network, the statistical characteristics represented by a curved exponential probability distribution of strength are understood by a 2-D network model which allows merging of nodes with intrinsic capacity. In the town network, the scaling law of traffic flow, distance, and population is explained by the gravity model observed in the interurban transportations [3, 4]. The two models shows that the rule of demand and cost is working under strong spatiality in an urban scale.

Keyword: Urban bus, Network, Gravity model

1. Bus stop Network

The bus stop network is a weighted network constructed by linking the neighboring bus stops which are directly connected with a bus line. In the probability distribution of strength, a curved exponential distribution is observed for every city. This curved distribution is explained by the "merging and cut-off" network model.

The 2-D spatial network model contains artificial bus lines passing through a downtown area and the bus stops are placed on the lines. As the weight of each bus line follows the linear exponential distribution given by the real data, the strength distribution has a linear exponential form before the merging and cutting-off processes. Merging of nodes occurs when a group of nodes are located within an arbitrary radius, since the real bus stops are not too closely placed due to cost efficiency. If the merged strength exceeds an arbitrary cut-off capacity, merging does not occur. This cut-off capacity represents the bus capacity of a bus stop in the real world, in order to avoid excessively high traffic concentration at a bus stop. After merging and cutting-off, the strength distribution shows a curved exponential form close to the real data. This result implies that the urban transportation network is constructed under strong spatial restriction.

2. Town Network

The scaling law of traffic flow, distance and population is studied on the town network. The towns connected by a bus line are linked and the weight is given by the daily bus traffic between them. The scaling law of the traffic (T_{ij}), population (P_i), and distance (d_{ij}) follows the gravity model which satisfies $T_{ij} \sim P_i^{\alpha_1} P_j^{\alpha_2} / d_{ij}^{\alpha_3}$ for all of the studied cities. The exponents are similar to those of the Korean express bus case [5], which are ~0.5 for population, and ~1 for distance. Since the traffic is proportional to the population and the inverse of distance, the transportation network in an urban scale is dominated by the rule of demand and cost.

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