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An Aggregation/Disaggregation Method of Units for Land use and Transport Analysis

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1. INTRODUCTION

The selection of "units for analysis" is the first step in building a quantitative model to analyze land use and transport. The units comprise of locator groups and land zones in the case of land use, and traveler groups and transport networks in transport. The units must suit with the objective of analysis as well as the nature of the phenomenon itself. In addition, the level of aggregation/disaggregation of units determines the accuracy of the model.

In the present study, an analysis system for integrated landuse/transport planning and implementation are dealt with. For this purpose, impacts of a variety of policy measures[1] should be evaluated. Some of the policy measures have some metropolitan wide impacts while others have some area-specific ones. In this sense, the analysis system should have some flexible functions by which units of analysis can be changeable. The aim of the present paper is to develop an aggregate/ disaggregate method of units for land use and transport analyses that satisfies the theoretical and numerical consistency between analyses at various levels of units from the coarsest to the most detailed.

2. ANALYTICAL FRAMEWORK

Probabilistic Choice Approach

The choice in location and transport system is characterized by a large number of alternatives. Thus in most applications the alternative in choice model is based on aggregate alternatives. The choices in this study are viewed as the outcome of a *probabilistic* process. Hence, the basis of the model building is an probabilistic choice approach. The model assumes that individual's evaluation of available alternatives and their attributes can be conceptually described by utility functions.

Let $P_n(i)$ be the probability of decision maker n choosing alternative i and V_{in} be the utility of an alternative. The simplest form of multiple choice probabilities are expressed by multinomial logit model (MNL) :

$$P_n(i) = \frac{\exp(\mu V_{in})}{\sum_{j=1}^{n} \exp(\mu V_{jn})} \quad \text{.....(1)}$$

where μ is the logit constant. Then the expected value of the maximum of the utilities are given by

$$S_i = \frac{1}{\mu} \ln\left[\sum_{j=1}^{n} \exp(\mu V_{jn}) \right] \quad \text{.....(2)}$$

This expression is commonly known as "logsum".

The aggregation/disaggregation method of units for analysis employs the probabilistic consistency which is satisfied by the nested logit model. In this sense, logsum function [eq.(2)] plays an important role in the procedures of both aggregation and disaggregation of units.

Elements in Analysis

To provide theoretical consistency in the analysis, all elements in representation of landuse and transport given in *Table 1* will be treated as choice situation correspond to multinomial logit model. Each analysis unit is described in terms of utility level, locational utility and travel utility. These utility functions would be aggregated by applying eq.(2).

Table 1 Landuse and transport elements in analysis

Elements	Landuse	Transport
Consumer	Locator group	Travelers
Alternatives	Location sites	Transport modes & routes
Demand attribute	Area occupied by locator group	Traffic flow on network
Supply attribute	Area available	Network capacity
Utility function	Locational Utility = f (bid-rent)	Travel Utility = g (generalized-travel cost)

The utility function of activity (locator group) in landuse elements are expressed as a function of land prices or bid-rent. The prices determine the locational utility that a given locator group will have if located in each zone. For transport elements, the generalized cost of travel are represented the utility of traveler. The transport demand given by the flows of activity are allocated to transport network and therefore modes, as a function of calculated utility. The travel utility is calculated at route level for assignment, then aggregated for all routes for modal split, and

aggregated for all modes to have the cost of travel between destination zones. Given the price, the utility can be estimated for both location and travel. The price of location is a combination of transport and land location.

3. AGGREGATION/DISAGGREGATION METHOD

Representation of Unit for Analysis

The structure of unit for analysis includes the representation of land use and transport elements. The raster-system is used to represent land use and land attributes. The raster-based structures involve the division of geographical area under study into series of grid cell. Each cell can become an analysis zone.

The concept of an aggregate or "sketch-planning" is adopted to represent transport network. The method employed is to transform original network into simply form of pseudo grid network. Zones in an aggregate system are covered by bi-directional links. Each zone's centroid is located at the center of a zone and is connected by two to four arterial or collector street links to produce a fairly regular grid network. Attributes coded for each aggregate link include beginning and ending node numbers, link length, the of area where link is located, link free speed, and link capacity. Link free speed is estimated for each link using area and facility types. The simple method of estimating aggregate link capacity is accomplished by summing the appropriate original link capacities crossing a zone boundary.

Level of detail and aggregation

The original network can be coded into three level of detailed network models: a fine, medium and coarse one. The fine model is nearly almost identical to the actual network. It includes almost all streets. The medium level is choosing such that it corresponds with normal transport planning practice. It includes all arterials and collectors. The coarse network model represents only the arterial.

An aggregate network is developed from original network. The first step in coding an aggregate network is selection of the system of analysis zone. Three analysis zone systems can be constructed: fine, medium and coarse zone. The higher level of aggregate zone systems are developed by combining zones in lower level into a suitable areal unit.

The aggregation process is performed in hierarchical basis. Zones and links of coarse network are an aggregation of zones and links of the medium network which are an aggregation of zones and links of the original network. A simplified representation of an aggregation/ disaggregation of landuse and transport systems is shown in Fig.1.

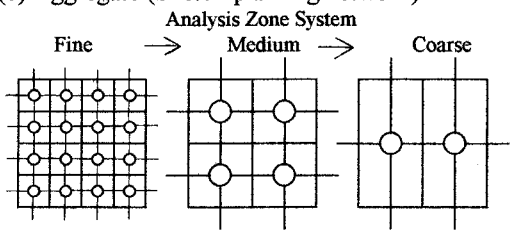
Fig.1 Aggregation/Disaggregation Representation

(a) Disaggregate (Original network)

Network detail

Fine	Medium	Coarse
Arterials Collectors Locals	Arterials Collectors	Arterials

(b) Aggregate (Sketch-planning network)



Disaggregation

The sketch-planning network also allows a wide range of policy options be tested. This operation requires an disaggregation method to translate the actions taken on the higher level of aggregate unit to the smaller unit at lower level. The strictly hierarchical relationships is an essential property of our proposed method in developing disaggregation scheme that guarantees the consistent network models and thereby enable an easier tracing of the effects of policy at different level of aggregation.

4.CONCLUDING REMARKS

The aggregation methodology is most likely applicable to long-range systems planning and strategic planning that deals with dramatic changes in supply and demand of landuse and transport such as in developing metropolises. The proposed method has been designed with simplicity of operation, but at the same time is capable of working with a wide variety of landuse and transport planning problems.

Reference

1) Udomsri, R. and K. Miyamoto. 1992. "Implementation measures for integrated transport, land use and environmental policies in developing metropolises". Proceedings of Infrastructure Planning, No.15(1), 967-972.