# Development of a Traffic Demand Simulator under a Disaster Restoration Period

Junji Urata[1], Takamasa Iryo[1], Riki Kawase[1]
[1]Department of Civil Engineering, Graduate School of Engineering, Kobe University, Japan

## 1. Introduction

This paper focuses on a traffic demand simulator under a disaster restoration situation. Transport network, houses and infrastructures of daily life, for example water, gas and electricity, are damaged by the disaster. These damages and humanitarian logistic occur severe traffic congestion [1]. Also, origin-destination (OD) demand pattern of citizens is changed from normal situation. The demand from or to main devastated zones will be rapidly increasing but the transport network does not prepare for an emergency demand but for a normal demand. This mismatch will occur heavier congestion and the carriage of required commodities will be delayed. The delays also produce a delay in a recovery of economic activity. This study develops a demand simulator in disaster restoration situation. The simulator will be important to predict a congestion and prepare before disaster.

## 2. Model

### Travel Purpose

Our simulator proposes an activity-based model under a disaster restoration period. The illustrative target of the periods is from 3 days after the occurrence of the earthquake until 2 weeks. A major travel purpose for citizens is getting food and water in this period. Humanitarian logistic comes in the devastated area but the trucks cannot convey directly to every shelters. Refugees should go to pick up essentials for life. These travel demands are excess [1]. Travel demand for commuting will be made a recovery gradually in 2 weeks. The demand can be easy to predict using an ordinary OD survey. This study models a behavior of commodity procurement. This behavior modelling will be useful for last mile distribution problem in humanitarian relief.

### Framework

This simulator introduces sequential choice behavior in agent-based modelling. People are difficult to have travel plan and predict travel and stay time under emergence situation. They cannot make a schedule and have a future forecast by lacks of information and experience. Our model introduces a process of sequential choice of a destination, transport mode and departure. Our simulator follows each agent to illustrate trip chain and returning home. Each agent has her/his home, activity history and commodities that are kept by her/him.

In a process of trip generation, agent chooses a candidate of destination and transport mode firstly. Next, agent chooses whether to depart to the candidate with reference to her/his information and neighborhoods behaviors. An ideal model is that agent chooses from a choice set. However, the number of combination of destination, mode and departure time is numerous and the algorithm for generating a choice set is not clear even in normal situation. Here, our proposed process of trip generation is iterated at short time intervals and the iterations have a similar effect to a model with a choice set. The total framework of proposed simulator is shown as Figure 1. Agent chooses his/her route and travel when she/he chooses to depart. This assignment calculation will be provided in different presentation of the symposium (Iryo et al. 2017). Agents have to wait at a distribution station and the waiting time depends on a number of people gathered.

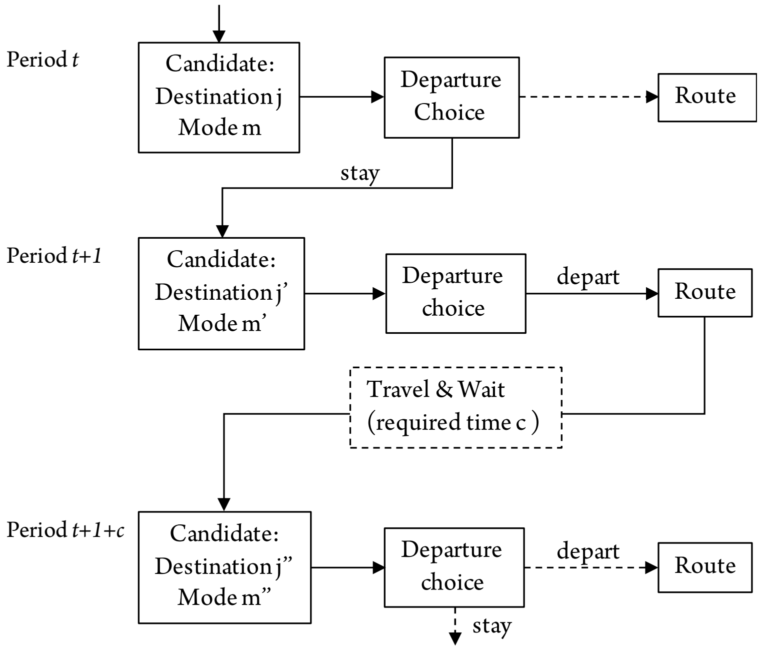


Figure 1 Agent's Sequential Choice of Destination, Mode and Departure

We calculate an interaction with neighborhoods who have or had the same destination candidates. In a disaster situation, people need the most recent information which is related to her/his accessible area. They can receive the information through neighborhood or very local media. Their behaviors will be influenced each other and we should model these interactions. However, there are enormous calculation cost if we apply full interaction network between all refugees. We apply the limited interaction with neighborhoods who have the same destination candidates.

## Destination and mode choice

This study introduces a stochastic destination choice model under uncertain situation [2]. A destination utility $U_{ijm}$ from zone i to zone j by mode m is composed of travel cost $C_{ijm}$, destination attractiveness $G_j$ and stochastic utility $\eta_{ijm}$. This stochastic utility shows a spatial correlation and its unobserved variation. The destination utility of agent a is

$$U^a_{ijm} = -C_{ijm} + G_j + \eta_{ijm}, \quad (1)$$

$$\eta_{ijm} = -\nu_{ijm} C_{ijm} \quad (2)$$

where $\nu_{ijm}$ is defined as Normal distribution which average is equal to 0. Agent from zone i to zone j by mode m is the same utility $\eta_{ijm}$ as spatial correlation. This stochastic spatial correlation produces a variation of OD demand patterns under uncertainty situation.

### Departure Choice

The departure choice model is based on formulae from Block and Durlauf (2001) [3]. The individual utility V of alternative $\omega_{at}$ of individual a at period t is given by

$$\mathrm{V}\big(\omega_{at}, \mu_{at}(\omega_{-at}), \varepsilon_{at}(\omega_{at})\big) = \mathrm{u}(\omega_{at}) + \mathrm{S}\big(\omega_{at}, \mu_{at}(\omega_{-at})\big) + \varepsilon_{at}(\omega_{at}), \quad (3)$$

$$\mathrm{S}\big(\omega_{at}, \mu_{at}(\omega_{-at})\big) = -E\left(\sum_{b \in N_{at,j}} \big(J|\delta_{\omega_{at}\omega_{bt}} - 1|\big)\right) \quad (4)$$

where $\mathrm{u}(\omega_{at})$ is the private utility associated with choice, $\mathrm{S}\big(\omega_{at}, \mu_{at}(\omega_{-at})\big)$ is the social utility, $\mu_{at}(\omega_{-at})$ is the conditional probability measure that describes the beliefs individual a possesses about the behaviors of others, J is the weight of interaction, $N_{at,j}$ is a group of individuals who are near individual a and go to zone j, $\delta$ is the Kronecker delta and $\varepsilon_{it}(\omega_{it})$ is a random utility term. The alternative $\omega$ is {1=depart, -1=stay}.

## 3. Discussion and conclusions

This study focuses on demand modelling under a disaster restoration situation. We model a behavior of getting a food and water by refugees. This simulator introduces a sequential choice process which includes the interactions of departure choice with neighborhoods. The introduced destination choice model can obtain a set of OD demand patterns which includes a variance of OD demand patterns by sampling many times. Behavior in a restoration period is uncertain. The simulator calculates iteratively for illustrating this uncertainty with capacity computing technique.

## References


[1] Kawasaki, Y., Kuwahara, M., Hara, Y., Mitani, T., Takenouchi, A., Iryo, T., Urata, J., Investigation of Traffic and Evacuation Aspects at Kumamoto Earthquake and the Future Issues, Journal of Disaster Research, Vol. 12, No. 2, pp. 272-286, 2017.

[2] Kawase, R., Urata, J., Iryo, T., Sampling approach on spatial variation for travel demand forecasting, 6th Symposium of the European Association for Research in Transportation (hEART 2017), No. 143, Haifa, Israel, September 12-14, 2017.

[3] Brock, W. A., Durlauf, S. N.: Interactions-based models, Handbook of econometrics, Vol. 5, pp. 3297-3380, 2001.