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# “Technical Research and Development for Road Policy Quality Improvement”
# Study Summary

| No. | Title | Principal Researcher |
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| No.25-2 | Study on road policy for achieving efficient and environmentally friendly freight transport | Kyoto Univ. Prof. Eiichi Taniguchi |

In order to develop a road policy considering the efficiency of logistics and the reduction of its environmental impacts, this research proposes a methodology for the freight vehicle traffic management. For this purpose, vehicle routing model with time windows (VRPTW) and multi-agent system (MAS) are developed to evaluate various city logistics measures.

## 1. Backgrounds and Objects

In order to consider the efficiency of logistics in a road policy, it is imperative to aim at a reliable road network with optimal travel times. However, many big cities suffer from the typical traffic related problems, such as heavy congestion, environmental emissions and accidents. To take full advantage of the available road network, management of the freight vehicles becomes very important for improvements in environment and traffic safety. Usually, the main objective of freight carriers and shippers is to reduce delivery cost, whereas, for other city logistics stakeholders (such as residents and administrators) improvement in environment, traffic safety and energy conservation are the main objectives. The road policy should aim at a balance between such private costs and public costs for the overall economic development of Japan. Therefore, the objective of this research is to work towards a methodology for truck traffic management to realize the road policy’s goal of efficient logistics and reduced environmental impacts.

## 2. Activities in Research Period

Data about the actual truck routes (115 in total) driven by four major logistics companies was collected using a probe device mounted on these trucks over a period of one month. The data was analyzed to study the pattern of truck routes in different land use districts. New VRPTW models considering the land use (VRPTW-LU) and considering the sensitive urban facilities (such as schools and hospitals) (VRPTW-SF) were developed to optimize the routes, which were then compared with the actual routes (probe data). In addition, behavior of various city logistics stakeholders (such as administrators, shippers and freight carriers) towards city logistics measures (such as joint delivery systems, green routes, etc.) was modeled using reinforcement learning in MAS. Many MAS simulations were carried using road network of Osaka prefecture to evaluate city logistics measures.

## 3. Study Results

As compared to the probe data, optimized routes using the VRPTW-LU resulted in less travel time in the exclusive residential areas, therefore, it can contribute in environmental improvement in these areas along with the cost optimization. Similarly, the VRPTW-SF model was able to reduce the number of passes and corresponding distance of the truck routes around hospitals, schools and nursing homes, therefore, it can also help in improving the environment as well as traffic safety conditions around these facilities.

City logistics initiatives such as eco points awarded to shippers/carriers by the administrators when they use environmentally better options (such as joint delivery system) or avoid roads with heavy NOx emissions (green logistics) were evaluated in MAS. It was observed that

implementation of combinations of policies (such as joint delivery system and green logistics) is more effective in satisfying diverse objectives (cost minimization and reduction in environmental impact) of city logistics stakeholder rather than individual policies.
The methodology of truck traffic management, proposed in this research, can be used in fostering the cooperation between various city logistics stakeholders (such as Freight Quality Partnership (FQP)). Simulated results of MAS and VRPTW-LU as well as VRPTW-SF can be used to discuss the costs and benefits of various city logistics measures before adopting them for their implementation or trials.

## 4. Papers for Presentation


1) Teo, J.S.E., **Taniguhi, E.** and Qureshi, A.G. Evaluation of urban distribution centers using multiagent Modeling with Geographic Information Systems, Transportation Research Record: Journal of the Transportation Research Board, Vol.2478, pp.35-47, 2015.
2) Teo, J.S.E., **Taniguchi, E.**, Qureshi, A.G., Mai, V.P. and Uchiyama, N., Towards a safer and healthier urbanization by improving land use footprint of last-mile freight delivery, 94th Annual meeting of Transportation Research Board, 2015.
3) 小川慶輔、**谷口栄一**、Ali Gul Qureshi、中村有克、Joel S.E. Teo、マルチエージェントシステムを用いた都市内物流施策の評価に関する研究、第５０回土木計画学研究発表会、2014.


## 5. Study Development and Future Issues

In order to implement the results or suggested city logistics measures of this research at the governmental level, the relevant data such as customers' demand, freight vehicle's movements (probe data), the actual road network, etc. will constitute a big-data. Therefore, development of appropriate meta-heuristics approaches (probably over parallel computing platform) would be essential to obtain results within feasible amount of time. Similarly, the behavior learning model of the stakeholders in MAS need to be improved (from the currently used reinforced learning) so that they can appropriately respond to their dynamically changing environment (such as changes in customers' demands, unexpected traffic congestion, etc.). Development of such advanced learning models, for example Adaptive Dynamic Programing (ADP) can be considered as future challenges.

## 6. Contribution to Road Policy Quality Improvement

The most important contribution is the idea of freight vehicle traffic management using the MAS. It can be used in FQPs to share the data between various stakeholders, such as freight carriers, administrators, shippers and most importantly to the residents of the area about the possible impacts of an individual or even a complex combination of various city logistics policies in simple terms, for example: reduction/increase in cost, reduction in NOx, CO2 and SPM emissions, reduction in number of trucks in the area and so on. Once such a policy or a combination is selected through the consultations in FQPs and implemented (or tried), the results can be feedback to the MAS and the PDCA cycle can be adopted for development of an efficient and environmentally friendly city logistics system. Logistics being the cornerstone of any local economy and a daily need of the residents and business community, an efficient system would contribute in the socio-economic development of the area as well as it would result in less load on limited road infrastructure. Therefore, an efficient city logistics system can contribute in improvement of quality of the road policy.

## 7. References, Websites, etc.

None