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A SIMULATION-OPTIMIZATION CONCEPTUAL MODEL OF AUTOMATED PARCEL LOCKERS ON MACRO AND MICRO PLANNING LEVELS

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ABSTRACT

Cities require goods and related logistics services, which has economic, political, environmental, and social implications. The research develops an simulation-optimization model for the implementation of automated parcel lockers (APL) as one solution for urban logistics (UL) operations. First, we consider a system dynamics simulation model (SDSM) to evaluate and predict the system behaviour in the macro planning level. Second, a facility location problem (FLP) is used for the micro-planning level to decide how many APL to open or close and where to locate them to minimize the total cost. We consider the dynamic behaviour of APL variables using the SDSM outputs as a inputs of an FLP and vice-versa. The aim of the model is to prevent an implementation failure of APL as a sustainable solution for the cities.

1 INTRODUCTION

The cities´ growing demand results in everyday problems such as deterioration of the urban environment and traffic congestion. Using automated parcel lockers (APL), such as packstations or locker boxes, is one of the most promising initiatives to improve urban logistics (UL) activities. The costs of APL deliveries are lower than for home deliveries and the risk of missed deliveries is avoided. Some studies confirm that online shoppers will use APL more frequently (Moroz and Polkowski 2016). Despite limitations to the concept, third-party logistics providers (DHL, InPost, Norway Post, PostDanmark, UPS, Amazon, and others) continue to invest in APL to gain a competitive advantage (Moroz and Polkowski 2016). Many studies did not look at their suitable locations, as well as the right capacity for seasonal peaks in e-commerce. Guerrero and Díaz-Ramírez (2017) remark that the APL strategy has not been discussed in the scientific literature, but is observed in practice. Understanding the APL systems regarding their behaviour and their interactions of the system components is a fundamental aspect to understand the potential impacts in the location of APL before their implementation.

2 CONCEPTUAL MODEL

The modelling framework seeks to link an SDSM with an FLP optimization model for macro and micro planning levels through an iterative process. From the hierarchical structure dimension of combining the simulation and optimization models’ point of view, we use alternate simulation-optimization (ASO), where both models run alternately in each iteration, either both completely or incompletely (Figueira and Almada-Lobo 2014), and the simulation model is regarded as a black box for the optimization (Figure 1).

For System Dynamics on the macro level planning, the research considers perspectives such as the social-economic behaviour; courier, express, and parcel services; e-customers; and APL service companies. To exemplify the model, using a piece of generic information, Figure 2(a) shows the stockflow diagram from the APL service companies' perspective with initial simulation values. Considering zero as initial time and ten as the final in years as time units, we propose three different scenarios: pessimistic (S1), realistic (S2), and optimistic (S3).

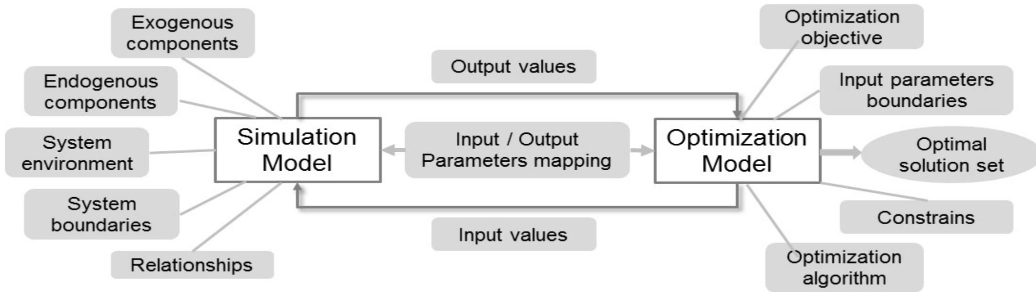
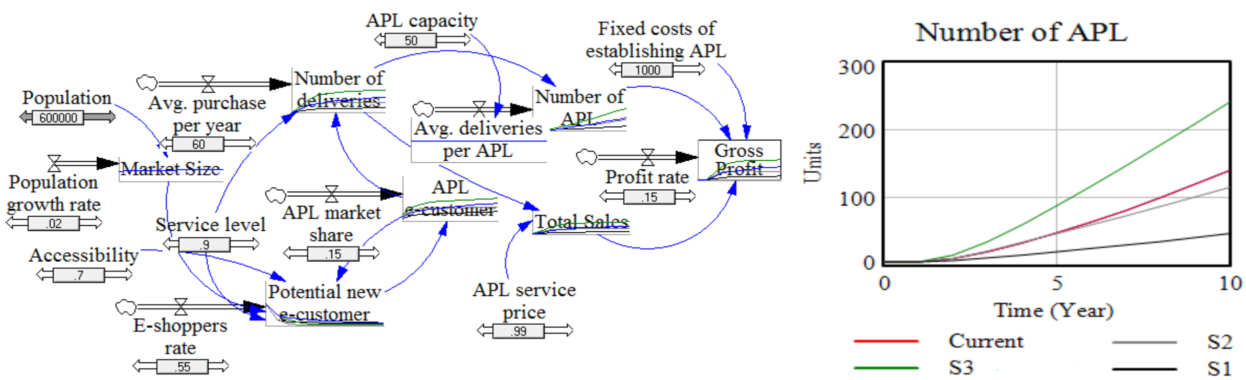


Figure 1: The general ASO process, adapted from Linnéusson et al. (2018).



(a) (b)

Figure 2: SDSM model; (a) model formulation and (b) resulting number of APLs for three scenarios.

In each scenario, we vary the accessibility as 40%, 50%, and 80%, the APL market share as 10%, 20%, and 25%, and the average purchase per year as 35, 50, and 70 units/year. The simulation started with five APL in the system. The simulation results in Figure 2(b) show for S1 (47), S2 (115), and S3 (241) the number of APL that the system needs at the 10th year.

Facility location problems for micro level planning consist of a set of potential facility sites where a facility can be opened. Considering the dynamic behaviour of the selected APL variables, we obtained the number of APL that the system needs each year in the next ten years. The number of APL are used as an input in the FLP model to determine the optimal or near-optimal locations of APL in each period in each scenario, respectively, linked in this way with the SDSM.

REFERENCES

Figueira, G. and B. Almada-Lobo. 2014. "Hybrid Simulation–Optimization Methods: A Taxonomy and Discussion". *Simulation Modelling Practice and Theory* 46:118–134.

Guerrero, J. and J. Díaz-Ramírez. 2017. "A Review on Transportation Last-Mile Network Design and Urban Freight Vehicles". In *Proceedings of the 2017 International Conference on Industrial Engineering and Operations Management*, 24th -25th July, Bristol, UK, 533–552.

Linnéusson, G., A. H. C. Ng, and T. Aslam. 2018. "Quantitative Analysis of a Conceptual System Dynamics Maintenance Performance Model using Multi-objective Optimisation". *Journal of Simulation* 12(2):171–189.

Moroz, M. and Z. Polkowski. 2016. "The Last Mile Issue and Urban Logistics: Choosing Parcel Machines in the Context of the Ecological Attitudes of the Y Generation Consumers Purchasing Online". *Transportation Research Procedia* 16:378–393.