Modeling of repositioning activities in Bike-Sharing Systems

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Climate changes, declining inventories of fossil fuels, high space requirements and noise emission are only a few reasons explaining the crisis of cars as individual means of transportation. Bikes receive increasing attention in city transportation, mainly because they reach areas in cities that do not have direct access to public transport. Furthermore they do not contribute to congestion or pollution of the environment. Traditional day rentals in tourism have evolved to modern Bike-Sharing Systems supported by information systems to provide easy and quick city wide access. Thus, Bike-Sharing Systems have rapidly emerged in major cities all over the world in recent years.

The planning and operations of such systems receive attention in academia as well as in practice. However, scientific literature in this field is still rather scarce. Recent articles focus on purely practical advises [1-3]. A common issue observed in modern Bike-Sharing Systems is imbalances in the spatial distribution of bikes over time occuring due to one-way use and short hiring times of bikes. The availability of bikes (= probability of successful bike rental) decreases nonlinearily with the number of requesting costumers in the system. The active repositioning of bikes to stations of potential customer requests supports the objective of maximizing the availability of service. This contribution assesses the prospects of operational repositioning services by means of an aggregate feedback loop model.

We refrain from building a spatial model, instead we adopt the approach of Karmarkar in the field of capacitated production planning [4]. Karmarkar has developed a nonlinear “clearing function” in order to model the output of a production system as a function of the average work-in-process. We adopt this clearing function to model the probability of successful rentals under a certain number of requesting users in the system. The clearing function also contains a parameter modelling the benefit of the repositioning effort with respect to the probability of a successful bike rental. This function is engaged in a system dynamics model [5] which allows insight in the dynamics resulting from different levels of repositioning activity. First a causal diagram is build to depict the general interdependencies of the Bike-Sharing business model. Second a inventory and flow representation is used to simulate the impact on the corporate performance of Bike-Sharing Systems under different effort spent on repositioning of bikes.

The findings from this model motivate repositioning activities in Bike-Sharing Systems and can be used to determine a reasonable effort spent on repositioning. The model is validated by means of the Bike-Sharing System “Citybike Wien” [6]. Results for different levels of repositioning effort are discussed.

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