# Reinforcement Learning and ABM for Traffic Signal Control

## 1. Introduction:

### 1.1 Background and Motivation

With the development of modern cities, more and more cars are driving in the traffic system, which not only results in significant time and economy wastage but also increases carbon emissions. As the UK Transportation Committee Chair Louise Ellman reported in 2011 said,” Congestion costs the economy billions of pounds each year”. Based on a previous inquiry, 'Transport and the Economy' shows that, by 2025, the cost of congestion will rise to an extra £22 billion per annum[[link](https://committees.parliament.uk/committee/153/transport-committee/news/177672/etm-report/)]. Thus, reducing traffic congestion is necessary and it is helpful for us to follow the UN Sustainable Development Goals.

One of the effect ways to reduce traffic congestion is the control of traffic signals in the existing traffic network. As Sunkari mentioned in his journal article, the project (Sunkari, 2004) on San Jose Boulevard in Jacksonville, FL, reduced average arterial delay by 35%, result in estimated annual fuel savings of 65,000 gallons and overall annual cost savings of $2.5 million in 2001. And another project (Sunkari, 2004) in Burlington, Canada, re-managed the signal pattern in 62 intersections, observed 7% savings in travel time, 6% savings in fuel consumption. And this project demonstrated annual savings of $1.06 million for delays and fuel consumption alone in 2001.

Therefore, it is of great significance to explore the optimization of traffic signal patterns in order to reduce economic and energy costs and make it possible to reach the UN Sustainable Development Goals faster. However, how to better optimize traffic light patterns has become a hot topic.

### 1.2 Research Question and Objectives

With the development of artificial intelligence, reinforcement learning shows its potential in decision and strategy making (Sutton and Barto, 2018). For traffic signal control, reinforcement learning enables signal control systems to dynamically adjust signal patterns based on real-time traffic conditions to achieve the goal of reducing congestion and optimizing traffic efficiency (Wei *et al.*, 2018; Wei, Chen, *et al.*, 2019; Wei, Xu, *et al.*, 2019; Zheng *et al.*, 2019; Chen *et al.*, 2020; Jamil, Ganguly and Nower, 2020). Furthermore, as a traditional simulation model, agent-based model has made a great contribution to traffic simulation (Dia, 2002; Cools, Gershenson and D’Hooghe, 2008; Shen, Wang and Zhu, 2011; Treiber and Kesting, 2013; Kühnel, Thunig and Nagel, 2018; Thunig, Kühnel and Nagel, 2019; Viridi *et al.*, 2019; Zhang *et al.*, 2019). Thus, the optimization of traffic signal patterns by combining agent-based model and reinforcement learning is a worthwhile research topic.

In order to contribute to the research in this field, the main aim of this paper is to try to come up with a traffic signal pattern which can reduce traffic congestion based on the traffic flow data of London. Hence, the corresponding basic research questions are put forward as follows:

What is the best strategy of the traffic signal when the intersection faced with different kinds of traffic flow?

Guided by this main question, there are several objectives for this paper which we list according to the analytical steps in this research. These are as follows:

1. Review the relevant literature and empirical studies on the use of reinforcement learning and agent-based model methods to optimize the traffic signal pattern.

2. Establish an agent-based model to simulate the scene of the intersection in the traffic network.

3. Define the reinforcement learning algorithm and train the model to get the optimal pattern of the traffic signal.

4. Quantitatively measure the result compared with the pre-defined traffic signal pattern.

5. Expand the method to the London traffic network and evaluate the result.

### 1.3 Research Scope

This study will focus on finding optimal traffic signal patterns using RL (reinforcement learning) and ABM (agent-based models). The research will focus on intersections to study the optimal control strategies for signals under different traffic flow patterns. The study does not include the control of other traffic control devices, such as road signs and crosswalks. Also, the study does not consider the influence of some microscopic traffic factors, such as pedestrians.

The geographic data and statistical data on London's transportation network used in this study are obtained from the London Department of Statistics. The time period is xxxx

### 1.4 Report Structure

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## 2. Literature review

There have been many related studies to optimize the traffic signal patterns and there are many ways to optimize the signal. Many researchers have made their contribution in this area. Most research mainly has three parts in their methodology. The first part is simulating the urban traffic system by using some methods, the second part is using different methods to investigate the most proper pattern of the traffic signal and the third part of is how to evaluate these methods and how extend it can integrate to the current traffic system. Depending on the different aspects, I discuss some of relative literatures with the following sections.

### 2.1 The evaluation of the traffic system

### 2.2 The application of ABM in traffic system simulation

### 2.3 The application of RL in investigation of the traffic signal

### 2.4 Conclusion

目前选择的方法是有效的、目前研究仍有一些困难、本文将会在XX层面做出XXX一定的贡献，填补XX的gap。

## 3. Methodology

## 4. Results and Discussion

## 5. Conclusion