# MULTI-LANE TRAFFIC FLOW MODEL

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## 1. Introduction

Our model is an extension of classic Nagel-Schreckenberg CA model, that imposes cars no changing their lanes. Multi-lane model however, allows cars to change lanes and conduct overtake manoeuvres. Motivation for creating our model was to examine how ability to overtake changes traffic flow in comparison to single-lane Nagel-Schreckenberg model.

## 2. Lane changing model

In our lane changing model an overtake maneuver is based on the rules listed below:

- When car is preceded by another car, in a distance that would imply decreasing speed in basic NaSch model, car tries to conduct an overtake maneuver
- We assumed that the car always going to stay on the lane it was spawned, which imply that after each overtake maneuver car tries to return to its previous lane
- We achieve the lane balance by some simple overtaking rules:
    - if the car is in its root lane, it first tries to overtake from left, than on the right
    - if the car has some offset to its left, it first tries to reduce it by returning right, then to stay on its current line and lastly to increase the offset by turning left again.
    - if the car has some offset to its right, it executes the similar maneuver as described above, but flipped horizontally.
- We assumed that the boundaries on sides are periodically as well

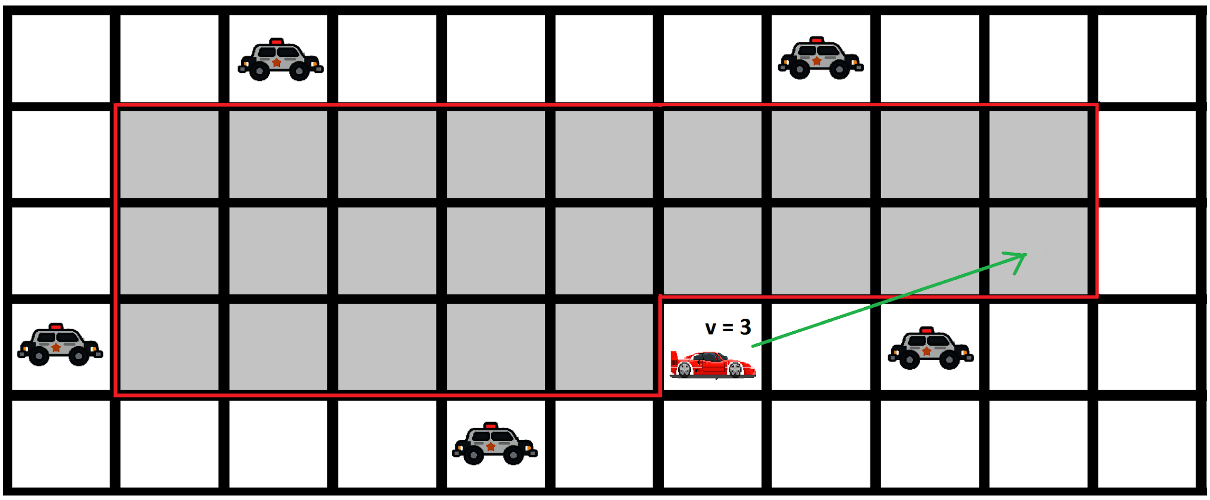
## 3. Overtake maneuver

To explain overtaking rules more precisely we introduce some signs:

- max_speed - maximal speed allowed in simulation on x axis
- car_speed - current car speed on x axis

In our simulation we denote speed as a vector, but to simplify diagrams, when it's not necessary we don't include y component. F.ex. v = 3 on diagram is equal to v = [3,0] in reality.

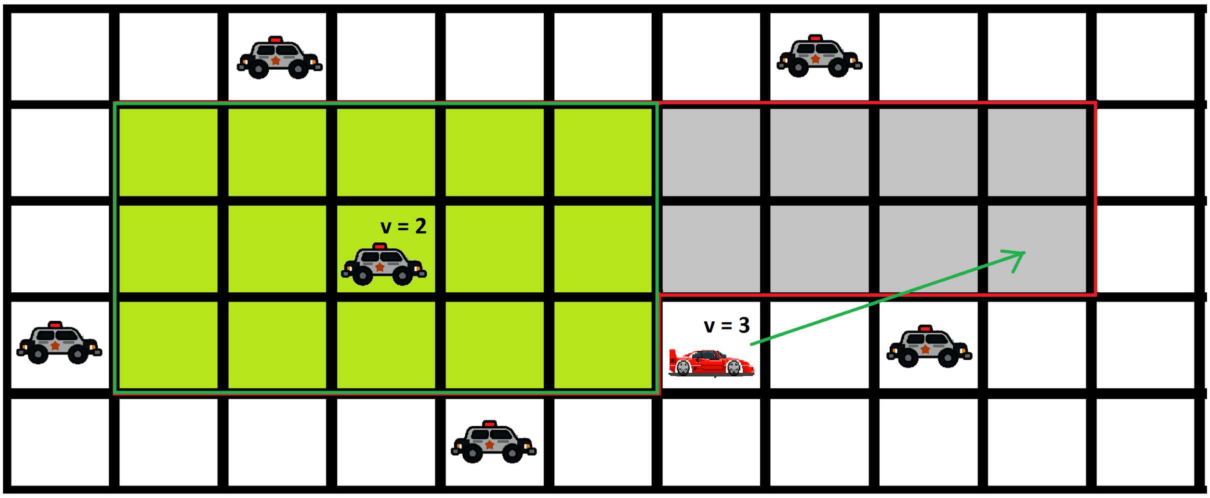
In our model we started from the basic rule of checking whether a car can overtake. In the image below (diag. 1) we presented how car checks if it can overtake.




*Diag. 1. Basic checking for a possibility to overtake from left*

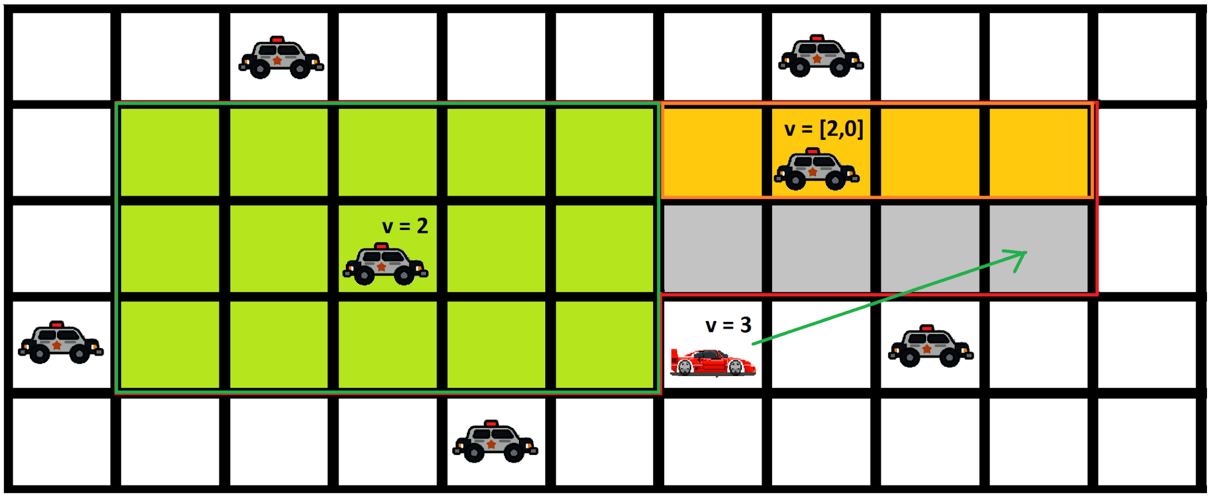
In this basic approach, checking if a car can be in position (x,y) is based on checking if there is no other car in the area marked in grey color. The area length can be presented as an interval [x-max_speed, x+car_spped] and 2 or 3 cells high, depending on x position. On the above diagram we presented checking left-side overtake. Checking right-side is based on the same approach, but flipped horizontally. This approach ensures a no-collision model, however is very restricted and doesn't satisfy all overtaking cases.

We decided to extend overtaking rules, so that it would include more overtaking cases. New approach is presented on the diagram (diag. 2) below.




*Diag. 2. Extended checking for a possibility to overtake from left*

In the extended approach we noticed that if any other car is in the green rectangle and its velocity is less or equal than its distance  to the red car (counted in free cells), then the red car can safely overtake. This approach also ensures a no-collision model and includes some overtaking cases that the basic approach would reject.
Finally, we made a second extension, that includes the behavior of cars driving 2 lanes above the overtaking car. The final approach is presented on the diagram below (diag. 3)




*Diag. 3. Final checking for a possibility to overtake from left*

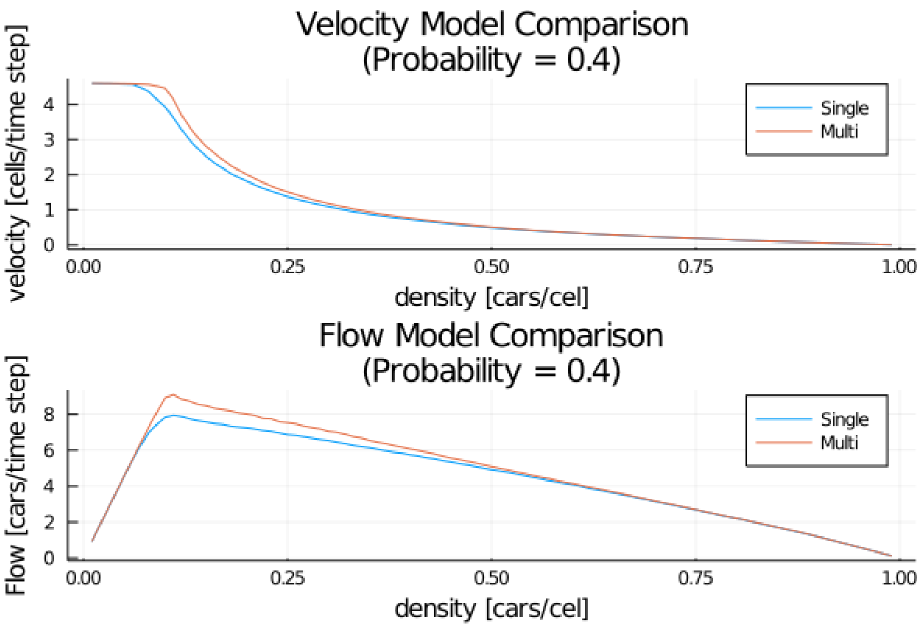
To ensure a no-collision model, cars in yellow rectangles can't overtake on the same lane the red car wants to overtake. If this condition is satisfied, the red car can safely overtake.

## 4. Commentary and Interpretation

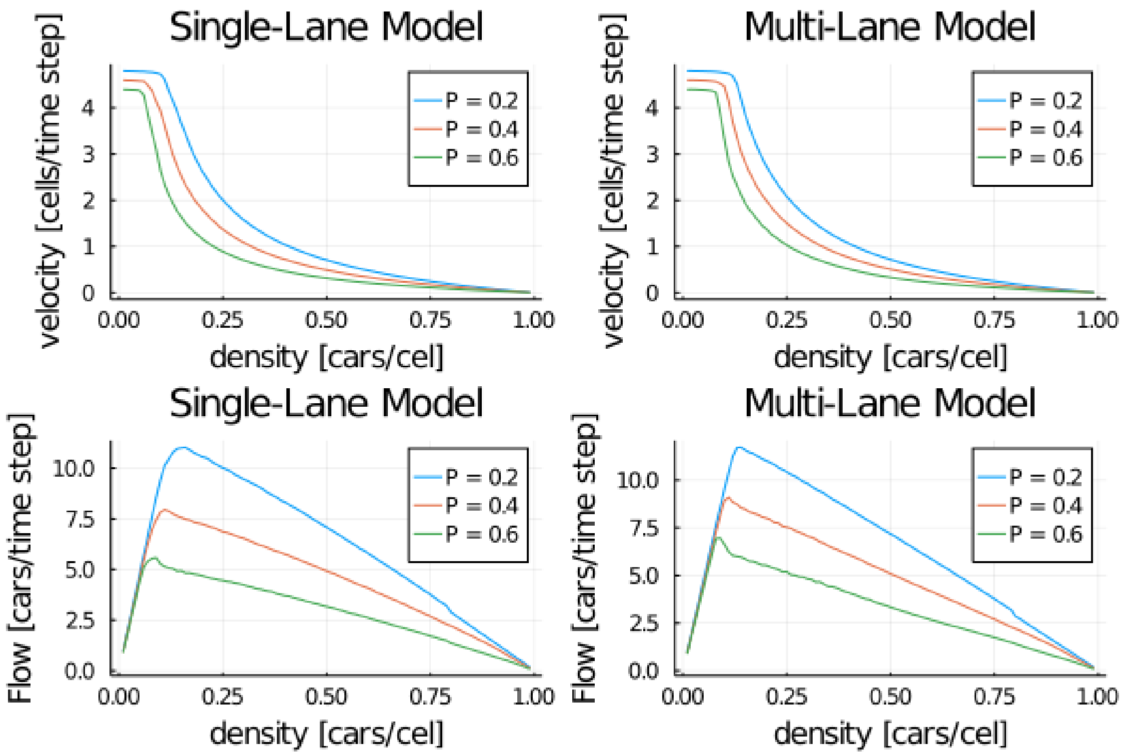
The aim of this model is to simulate traffic on a busy road. In most countries drivers are supposed to keep to the right side of the road and overtake on the left (faster lane). We tried to achieve this by preferring the left-side overtake. Our model simulates the driver changing lanes who checks the frontend  as well as backend in order to perform the maneuver safely. The driver also inspects the velocity of cars behind him.

## 5. Comparison with basic Nagel-Schreckenberg model

We have compared the models by running some tests with different parameters as shown below on the diagrams:




*Diag. 4. Top - the difference in velocity in each model; Bottom - the difference in flow in each model.*




*Diag. 5. The collection of different charts which shows the difference in model behavior corresponding to various deceleration probability* P.

## 6. Conclusion

As we can see, the improvement in both velocity and flow is not significant. That may be the result of quite a big constraint on overtaking. In reality drivers may behave more risky. Another explanation is the use of indicators on the real road, which  helps to estimate whether or not to start overtaking. We have not implemented those in our model.