**Problem Description:** Traffic congestion on the road is one of the major problems faced by most of on daily basis. Today most of the traffic signal operates on either manual traffic light control or a fixed time interval for each lane. Both the approaches are unable to solve the congestion issue faces by us and we end up wasting a lot of time on road which leads to higher commute time.

**Proposed solution:** Reinforcement learning can be applied to control the traffic signal. Agent can learn from the running traffic and control the traffic signal efficiently. This can reduce the overall waiting time for vehicles on the signals.

To approach this problem, we have used different TD learning algorithm such as SARSA, Q-Learning and Double Q-Learning.

**SARSA On-policy TD Control**

**Q-Learning Off-Policy TD Control**

**Double Q-Learning TD Control**

By changing Q2 to Q1 with 0.5 probability.

Here agent observes the traffic (state) and takes the action (green signal for the lane) and attain the reward (vehicle waiting time). The state and action pairs are stored in q-table, where values are continuously updated after each learning until it converges, and an optimal policy is found.

Below is the detail definition of Q-learning RL attributes

**State**: -

1. Current Phase - Current phase set on traffic signal for the specific lane
2. Elapsed time - Time spent on current signal
3. Lane density - last step vehicle on lane / (lane length / vehicle size (along with min gap between vehicle)
4. Queue length - Last step halting/waiting vehicle on lane / (lane length / vehicle size (along with min gap between vehicle)

**Reward:-**

Total waiting time for all the vehicles on the traffic signal

**Action:-**

which phase should be set green next

* single intersection, single road-single lane - phase - 0, 1 (action - 0/1)
* single intersection, two road - single lane - phase 0,1,2,3 (action - 0/1/2/3)
* single intersection, two road - double lane - phase 0,1,2,3,4,5,6,7 (action - 0/1/2/3/4/5/6/7)

**Simulation:** To simulate traffic signal, we have used SUMO platform (1). It offers rich set of API’s to simulate real traffic scenarios. For our study we have used two road one-way intersection and two-way intersection. Due to time constrain we have only used single intersection.

**Simulation parameters:**

Time step – 100000

Gamma – 0.9

Alpha – 0.1

Epsilon – Decay

**Simulation Results:** To show our agents learning and control mechanism we have plotted the graph between Time Step and Total Waiting Time of Vehicle for each TD control Algorithm. We have also compared RL algorithm with Fixed time green signal based traffic signal control.

1. One-Way Single intersection traffic signal control using fixed timing green signal



1. One-way single intersection using Q-learning



1. One-way single intersection using SARSA
2. One-way single intersection using Double Q-Learning
3. Two-way single intersection using Q-Learning
4. Two-way single intersection using SARSA
5. Two-way single intersection using Double Q-Learning