Title: A Simulation Study on Adaptive Traffic Light Control

1. Objective
   1. This project focuses on optimizing traffic light timings based on real-time traffic flow, improving efficiency at intersections, and reducing congestion. In this study, you need to simulate an adaptive traffic light control system that adjusts signal timings dynamically based on current traffic conditions to minimize congestion and improve traffic flow.
2. Simulation Scope
   1. Intersection
      1. Model a single busy intersection with multiple lanes for each direction,  
         e.g., 2 lanes per road in a four-way intersection.
   2. Traffic Flow
      1. Simulate traffic flows varying throughout the day, e.g., rush hour, low traffic times. You may assume that the car arrives at the intersection in each possible direction follow Poisson arrivals. Possible directions include straight southbound, straight northbound, straight eastbound, straight westbound, northeast right turn, northwest left turn, and so on. In your simulation, you need to define the traffic rules,  
         e.g., a right turn is possible only when no car is on the destination lane; a left turn is possible only when the traffic light is green, and the opposite and the destination lanes have no car.
   3. Traffic Light Control
      1. Implement traditional fixed-time traffic signals as a baseline and compare it to an adaptive traffic light system that responds to real-time traffic conditions. To simplify, we assume the traffic lights have no left-turn signal.
3. Traffic Light Control Models
   1. Scenario 1 (Baseline): A traditional fixed-time traffic light system where each direction has a set green light duration (e.g., 30 seconds per direction) regardless of traffic conditions.
   2. Scenario 2: An adaptive traffic light system that dynamically changes green light durations based on the real-time traffic flow (e.g., extending green lights when more vehicles are present). Here, you have the freedom to propose/study your strategy.
4. Performance Metrics
   1. Track these key metrics to evaluate the performance of your traffic light control strategies:
      1. Average waiting time: Measure the average time that vehicles spend waiting at the intersection.
      2. Throughput: Count the number of vehicles that pass through the intersection within a given time frame.
      3. Queue length: Track the maximum and average queue length at the intersection.
      4. Traffic flow efficiency: Measure how quickly the intersection clears vehicles during peak and non-peak hours.
5. Project Workflow
   1. Scenario Analysis: Simulate multiple traffic scenarios (e.g., morning rush hour, low traffic at night) for both fixed-time and adaptive systems.
   2. Performance Analysis: Use the metrics to compare the effectiveness of adaptive vs. fixed-time traffic lights. Analyze how much the adaptive system improves vehicle throughput and reduces waiting times.
   3. Conclusion: Summarize findings and your adaptive traffic control strategy in reducing congestion and improving overall intersection efficiency.