

# Smart traffic lights to help cars save gas 

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#### Abstract

Intelligent driver systems and vehicle connectivity have made systems like RFID based traffic control systems, automatic collision notification obsolete. In addition to collision notification, cooperative collision avoidance and other applications using connectivity between the vehicle and signalized intersections have emerged. Applications avoiding collisions, enhancing fuel economy and reducing greenhouse gases (GHG) are the subject of this paper. The interaction between vehicle and traffic management systems could revolutionize the traffic problems of a crowded metropolitan city. This paper will employ connectivity as an enabling technology for sustaining the vision of smart and green transportation systems.


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## Introduction

Of the almost 34,000 fatalities on U.S. roads in 2010, almost 21 percent of deaths take place at intersections. Smart intersections, paired with Connected Vehicle Technology could greatly reduce that number. The implications of this technology are enormous - it could save your life, save you gas and even reduce the time you spend commuting in the daily grind.

Growing numbers of road users and the limited resources provided by current infrastructures lead to ever increasing traveling times. Today's car-sensing lights stay green in one direction until a car wants to enter the intersection from the cross street, when the light is directed to change based on sensor data from a loop of wire in the roadway. Instead a system could be developed which uses short-range wireless transmitters (like a WiFi router) in cars and elements of the road infrastructure commonly known as V 2 V (for vehicle to vehicle) communications.

It would use messaging between vehicles and the trafficlight controller to let the light make better decisions about when to change, to maximize overall vehicle throughput. And that, in turn would reduce the number of minutes cars spent idling at traffic lights, cutting their emissions and their fuel usage.
In other words, cutting red-light time helps you go green.
Intelligent traffic light control does not only mean that traffic lights are set in order to minimize waiting times of road users, but also that road users receive information about how to drive through a city in order to minimize their waiting times. This means that we are coping with a complex multi-agent system, where communication and coordination play essential roles. This paper presents a system in which traffic light controllers and the behavior of car drivers are optimized using machine-learning methods.

## System Architecture

Our idea of setting a traffic light is as follows. Suppose there are a number of cars with their destination address standing before a crossing. All cars communicate to the traffic light their specific place in the queue and their destination
address. The transceivers in the car send information about its speed, distance of the vehicle from the traffic light, vehicle type, and relative volume of the vehicle.

The position of the vehicle with respect to the traffic light is garnered from the GPS tracking system.

Other vehicle information including data on whether a car was accelerating, braking, or flashing a turn signal would all factor into signal timing--including the duration of optional features like turning-lane arrows is sent on subsequent data frames.

Now the traffic light controller has to decide which option (ie, which lanes are to be put on green) is optimal to minimize the long-term average waiting time until all cars have arrived at their destination address. The learning traffic light controllers solve this problem by estimating how long it would take for a car to arrive at its destination address (for which the car may need to pass many different traffic lights) when currently the light would be put on green, and how long it would take if the light would be put on red. The difference between the waiting time for red and the waiting time for green is the gain for the car. Now the traffic light controllers set the lights in such a way to maximize the average gain of all cars standing before the crossing. To estimate the waiting times, we use 'reinforcement learning' which keeps track of the waiting times of individual cars.

The signal controller triggers the pre-empt green light extension decision device to increase the green light time. This decision is communicated to the vehicle by sending a signal through the transceiver installed on the traffic light. This signal informs the driver of the vehicle about the change in the light timings. It also advises the driver what speed, within the legal limit, they should drive to make all the greens.

One nice feature is that the system is very fair; it never lets one car wait for a very long time, since then its gain of setting its own light to green becomes very large, and the optimal decision of the traffic light will set his light to green. Furthermore, since we estimate waiting times before traffic lights until the

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destination of the road user has been reached, the road user can use this information to choose to which next traffic light to go, thereby improving its driving behavior through a city. The traffic light control problem is solved by using a distributed multi-agent system, where cooperation and coordination are done by communication, learning, and voting mechanisms. To allow for green waves during extremely busy situations the system could employ the transmission of gain from one four way intersection to another.


Fig1. System architecture
Besides controlling the traffic light timings, this system prevents collision of cars by using vehicle to vehicle (or V 2 V ) communication.


Fig2. Example of two adjacent vehicles approaching a four way intersection along predefined paths.
The system utilizes vehicle-to-vehicle (V2V) Dedicated Short-Range Communications (DSRC) to share critical collision information. Safety is achieved in potential collision scenarios by controlling the velocities of both vehicles with brakes. The intersection collision avoidance could be employed where a driver turns right at a red light without properly (or incorrectly) surveying oncoming traffic. This is possible because of communication between vehicles.

We assume each vehicle is equipped with sensors for state measurement (absolute position, heading, velocity, acceleration, brake torque, and pedal position), non-interrupted V 2 V
communication, and the ability to automatically actuate the throttle and brake.

If the vehicle 1 turning right enters the intersection before vehicle 2 , ICA will issue a throttle command to the vehicle turning right, while simultaneously issuing a brake command to the oncoming vehicle. The acceleration and retardation of vehicles is kept within the permissible speed limits. This implies that automatic control commands applied to prevent collisions at the intersection do not create dangerous driving conditions for other vehicles not directly involved.

Collision is detected based on the assumption that once a route decision is made, drivers obey the determined path when driving through the intersections. These paths are defined by driving lanes, and drivers do not change lanes once they enter the intersection. These assumptions help in developing models for collision between two or more vehicles as a set of vehicle configurations on these paths as seen in the figure.

One of the major problems we face in India is that there is construction work in place in many of the roads due to plenty of reasons such as filling up the potholes, burst pipeline below the roads, road blockage due to acccident or due to felling of a tree to name a few. This construction work causes a lot of trouble espicially if it on a major road. And in all the cases, the motorist are completely unaware of the blockage and come to know only when they enter the road and are stuck in heavy traffic. This paper exploits an excellent technique by which the problems faced due to blockages can be avoided.


Fig3. Radio beacon near a construction.
As mentioned previously, the GPS system installed in the vehicle calculates the path which the motorist take in order to reach the destination. Now, whenever there is a blockage or construction work is in place, the workers would place a radio beacon at the subject site. This beacon would transmit name of the road and magnitde of the blockage and these would be received by the recievers in all the vehicles and forward the signal to the GPS system installed inside the vehicle. Here, we define 3 catagories of blockages as follows :

| Catagory | Meaning |
| :--- | :--- |
| Level 1 | Road partially blocked |
| Level 2 | Road half blocked |
| Level 3 | Road full blocked |

Based on the level of signal received and the size and weight of the vehicle, the system will decide whether to follow the same path and move on towards the road or take a different path to reach the destination. Depending on the decision, the GPS system will inform the systems placed on traffic signals and the traffic signals can determine the rate of traffic in respective directions.

## Conclusion

Traffic control is a very complicated non-linear field of study. One of the major complications is deciding what will be the goal of assembling a linked system of traffic controls; maximizing major artery flow, minimizing accident occurrence, minimize likely fuel consumption, and increase traffic capability with existing roadways. Very similar to the uncertainty principle of quantum mechanics, a traffic system can be designed to only try to achieve one of these goals. Compounding this difficulty in design is that the traffic flow itself is a random process condition that varies on the time of day and that change with urban development.

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