The Use of V2X Communication in Autonomous Transportation

Problem
Modern roads have issues of safety, efficiency, and environmental health that decrease quality of life.

In the United States, 94% of crashes involve poor human choice or an error in judgment.

In 2014, 1.25 million people worldwide died in vehicle crashes, over 25% of which occurred in intersections.

Traffic congestion costs Americans $124 billion a year.

World Health Organization estimates that in 2008, 50% of the world’s population lived in urban areas, and this number is expected to be nearly 70% by mid-century.

In the US in 2011, traffic congestion accounted for 56 billion pounds of carbon emissions, according to the Texas A&M Urban Mobility Report.

Solution
Vehicle to Everything (V2X) communication is a sustainable solution that allows vehicles to communicate with their surroundings, greatly increasing the safety and efficiency of driving.

Electrical Design of V2X
Short Range Communication

V2X is a communication system that works on an isolated network of signal wavelengths known as Dedicated Short Range Communication (DSRC). DSRC is the original electrical technology embedded in vehicles that allows onboard computers to receive data from outside sources. DSRC transmits signal wavelengths in which a vehicle publicly exchanges its location, speed, and intended direction with other vehicles within a range of 300 meters at a rate of 10 times every second.

V2X message sets can contain data that must be evaluated autonomously by onboard computers. Using mathematical algorithms and programming, engineers can enable a car to make informed decisions and navigate roadways without human intervention.

AIM
Autonomous Intersection Management (AIM) is a system that uses Vehicle to Infrastructure communication to guide autonomous and semi-autonomous vehicles through an intersection, greatly increasing safety and efficiency. This system is a sustainable solution to the multitude of road problems we face today.

Creating an Autonomous Network
V2X allows for the creation of a Vehicular Ad-hoc Network (VANET), which is a collection of connected vehicles and civil infrastructure.

VANET allows cars to receive and interpret pertinent data in real-time and removes a human driver from the transportation experience. Conceptually, a VANET is simply thousands of V2X enabled devices communicating in a vast network at once. This has amazing potential, as it would allow any V2X enabled vehicle to collect enough data about its environment to make the decisions necessary to drive autonomously.

How AIM Works
1. An “Intersection Manager” (M) computer associated with a specific intersection divides the intersection into a virtual grid.
2. Vehicle calls ahead to the IM and sends information on its size, predicted arrival time, velocity, acceleration, and current lane.
3. IM checks to see if the vehicle’s potential path is clear. If yes, it makes a “space-time reservation” for the vehicle.
4. If there are already reservations in the grid cells of the vehicle’s path, IM makes an alternate reservation for the vehicle.
5. Vehicle’s request is rejected because at time t of its simulated trajectory, the vehicle’s space-time request has no conflicts at time t. If yes, it makes a “space-time reservation” for the vehicle.
6. The vehicle’s path, IM makes an alternate reservation for the vehicle.

Impacts of AIM
The AIM system reduces the delay per car by up to two orders of magnitude when compared to traffic signals or stop signs. It would effectively eliminate intersection-related collisions and traffic congestion by taking away the human factor of navigating intersections.

Impact Table

<table>
<thead>
<tr>
<th>Lanes</th>
<th>Average delay (s)</th>
<th>Max delay (s)</th>
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</thead>
<tbody>
<tr>
<td>AIM Intersection</td>
<td>Traffic Signal</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.016</td>
<td>0.912</td>
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<tr>
<td>2</td>
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<td>6</td>
<td>0.025</td>
<td>1.926</td>
</tr>
</tbody>
</table>

As seen in the above data table, the average delay of the AIM intersection in all cases is significantly lower than that of the traditional traffic signal. The maximum delay with the AIM intersection never got above 2 seconds.

Conclusion
V2X technology provides great potential for revolutionary change to civil engineering design of roadway systems. Not only does V2X communication open the doors to autonomous vehicles and all the benefits that come with them, it also introduces the possibility of redesigning cities to be safer, more sustainable, and more livable.