V2X Communication: Tackling Traffic Congestion Problems and Challenges

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Abstract: V2X interaction holds promise of revolutionary improvements and upgrades to transportation—reduced road construction, reduced number of accidents, greater fuel efficiency, and safety of vehicle occupants as well as motorists and pedestrians. This seamless communication and control over such automation of road traffic is a key contributor in discipline for such interactions.

Keywords: V2X, Traffic congestion, Communication, Vehicle, Protocol

I. INTRODUCTION

Traffic congestion is a crucial problem of urban areas. The scenario shown below gives an idea about the traffic jam.

![Traffic jam scenario](image)

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Vehicles today for the most part operated by humans and this results in late response time and delays in human reactions. When, in an ideal situation, where each vehicle is uniformly accelerating and decelerating, traffic is flowing smoothly with no cause for congestion or stoppage. A single interruption such as a car turning, a person arbitrarily crossing the road or one of the drivers slowing down to see something – causes a chain reaction which leads to trailing vehicles slowing down. The result of this is certain preceding vehicles completely coming to a halt. Now a larger implication of this may create a backlog of vehicles thereby creating an empty congestion – meaning a disruption without the cause of a physical challenge to flow of traffic (such as a breakdown or accident).

In the above scene, a group of standstill vehicles defines traffic jam. Situations are worse than as described above. It starts due to several reasons such as driver's misbehavior, accident on the road, obstacle on the road, weather conditions etc.

In the above scene shows congestion could also occur due to an accident. Result of this is, vehicles are either standstill or moving with very low speed resulting in time lapse and also wasting large amount of fuel. Traffic jam can get resolved within several hours or in critical condition it may take few days to get resolved. Thus, congestion affects economy as well as it gives bad impact on the environment. Due to this many Automobile industries are taking initiative to find efficient solution for congestion control. Following table gives an idea of various causes of congestion.
Table 1 Congestion Statistics

<table>
<thead>
<tr>
<th>Causes of congestion</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottlenecks</td>
<td>40</td>
</tr>
<tr>
<td>Traffic incidents</td>
<td>25</td>
</tr>
<tr>
<td>Work zones</td>
<td>10</td>
</tr>
<tr>
<td>Bad weather</td>
<td>15</td>
</tr>
<tr>
<td>Special events</td>
<td>5</td>
</tr>
<tr>
<td>Poor signal timing</td>
<td>5</td>
</tr>
</tbody>
</table>

II. THE NEXT STEP

Exploring the next big future step towards intelligent road transportation systems and networks—a system, or network of systems, consisting of many automobiles and their respective drivers interacting emerges on roads. Two directly interlinked fields of interaction arise as prospects:

- Vehicle-to-infrastructure (V2I) interaction
- Vehicle-to-vehicle (V2V) interaction

2.1. Vehicle-to-Infrastructure Control

In V2I, the infrastructure plays a coordination role by gathering global or local information on traffic and road conditions and then suggesting or imposing certain behaviors on a group of vehicles. One example is ramp metering, already widely used, which requires limited sensors and actuators (measurements of traffic density on a highway and traffic lights on ramps). In a more sophisticated scenario, the velocities and accelerations of vehicles and inter-vehicle distances would be suggested by the infrastructure on the basis of traffic conditions, with the goal of optimizing overall emissions, fuel consumption, and traffic velocities. Suggestions to vehicles could be broadcast to drivers via road displays or directly to vehicles via wireless connections. Looking further ahead, in some cases suggestions could be integrated into the vehicle controls and implemented semi automatically (always taking onto account the restrictions on automatic vehicle driving imposed by the Vienna Convention on Road Traffic, discussed later). Some experts predict that the first V2I systems may be developed and deployed in the 2015—2020 time frame.
The figure on the left shows two different traffic situations. In the left panel, traffic density is low and the central infrastructure based controller acts to improve fuel efficiency and reduce emissions of individual vehicles, smoothing accelerations and decelerations; in the right panel, due to greater congestion, the infrastructure control is primarily concerned with depleting queues at intersections with an eye toward global fuel economy and emissions reduction.

2.2. Vehicle-to-Vehicle Control

V2V, more difficult to realize because of its decentralized structure, aims at organizing the interaction among vehicles and possibly developing collaborations among them. At this level, information is interchanged and decisions are made on a “local” basis (that is, among a group of vehicles in proximity to each other). The introduction of such information interchange requires an agreement among car manufacturers and suppliers in terms of communication technology, protocols, and the like, and efforts are under way in this direction (the CAR2CAR Consortium). The communication technology is based on IEEE 802.11, also known as Wireless LAN. A frequency spectrum in the 5.9-GHz range has been allocated on a harmonized basis in Europe in line with similar allocations in the U.S. (although the systems are not yet compatible).

In the V2V concept, when two or more vehicles or roadside stations are in radio communication range, they connect automatically and establish an ad hoc network enabling the sharing of position, speed, and direction data. Every vehicle is also a router and allows sending messages over multi-hop to more distant vehicles and roadside stations. The routing algorithm is based on the position of the vehicles and is able to handle fast changes of the network topology. Control technology comes into play at local and higher layers of the architecture. Uncertainties, delays, partial measurements, safety and performance objectives, and other aspects must be considered, and the system must be capable of making automatic or semiautomatic decisions, providing warnings/information and potentially effecting actions.

2.3. Challenges

- In V2V the connectivity between the vehicles may not be there all the time since the vehicles are moving at different velocities due to which there might be quick network topology changes.
- The anonymity problem: The addresses of vehicles on highways are unknown to each other.
III. PROPOSED SOLUTIONS
A possible method for traffic congestion control is using VANET. Traffic congestion control can be achieved by broadcasting messages to vehicles in an area. The proposed communication is vehicle to vehicle communication as well as vehicle to infrastructure communication. The vehicle is equipped with a communicating device. The communication is initialized by the affected vehicle. The vehicles which are involved in the communication are called as nodes. These nodes are mobile in nature hence while selecting the communication pattern this mobile nature has to be considered. In MANET, all the nodes are fixed, hence if we try to apply same protocols for VANET packet loss takes place. To avoid this, an intelligent communication pattern has to be chosen.

3.1. Wireless Access in Vehicular Environment
There are greater challenges in wireless traffic patterns. To know the challenges of IEEE MAC layer operations for vehicular communication scenario, IEEE802.11p Wireless Access in Vehicular Environments (WAVE) was introduced. 802.11p is an IEEE standard that supports Real Time Traffic Transportation Systems (RTTS) ITS) applications in the context of vehicle to vehicle(V2V) and vehicle to infrastructure communications(V2I) that are being developed, namely the DSRC (Dedicated Short Range Communications) operating in 5.9 GHz band. WAVE has become a standard that can be universally adopted across the world. At present DSRC based on the Wi-Fi standard is widely used in VANETs as it connects infrastructure to vehicles and also vehicles to vehicles using two-way short range radio which is of lower costs compared to other wireless standards available. DSRC/WAVE systems fill a niche in the wireless infrastructure by facilitating low latency, geographically local, high data rate, and high mobility communications.

3.2. Communication Pattern
Here for proposed method the proposed communication pattern is Geo broadcasting. The messages are not transmitted periodically; they are transmitted only in case of external event occurrence. Message transmission is unidirectional. The message is transmitted to all the vehicles which are coming in the specified range, hence Omni directional antenna is used for broadcasting and the unidirectional forwarding is achieved by rejection of messages if from behind or from another lane. Communication is single hop communication and message forwarding is done by the next vehicle in range.

IV. CONCLUSION
Vehicle to Vehicle and Vehicle to infrastructure communication is an interesting and challenging field in communication network research which can widely impact the way we view road travel and rid off congestion. While many innovative, creative and technological new solutions have already been proposed, still many open issues exist. In addition to technical breakthroughs, the phase of market introduction and implementation is critical for the success of this new technology apart from the initial setup costs. VANETs will only become a commercial and technological success as long as their services and capabilities are of high value and returns to potential users during all phases of the
introduction, testing and implementation phase. Hence, services and technology have to be adaptable to the different levels of market penetration. Quality of Service (especially concerning latency) and security for VANET systems are crucial aspects of V2X communication that need to be integrated to ensure the success of this promising technology.

REFERENCES