Efficient Selection of Relay Vehicle for Accident Reporting in VANETs

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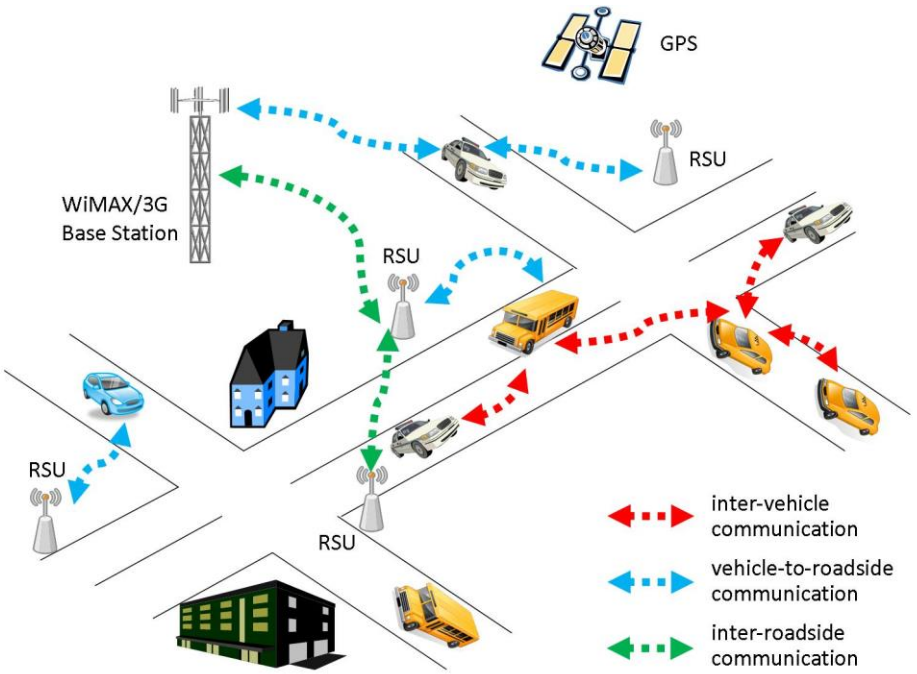
Vehicular Ad-Hoc Networks (VANETs)

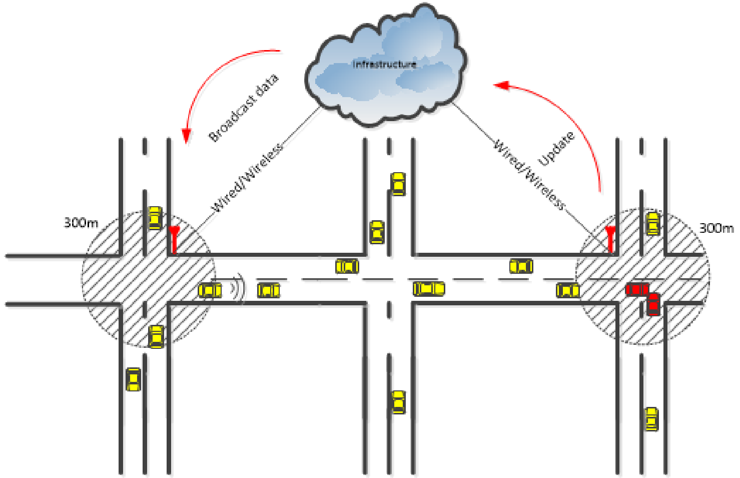
Application of mobile ad-hoc network principles to the vehicular domain.

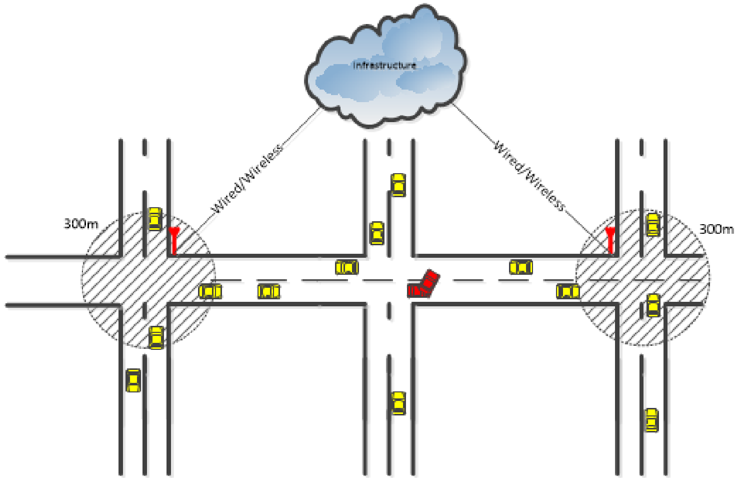
Can be purely vehicle to vehicle (V2V) but may also incorporate the use of roadside units (RSUs) in vehicle to infrastructure (V2I) communication.



Challenges

Roadside Units (RSUs), as a communication node, play a chief role in providing high-quality communication in VANETs. However, deploying an ideal number of RSUs is not feasible at the initial stage of VANET vastly owing to the considerable placement and maintenance costs. Therefore, not all parts of the roads can be covered by RSUs. This culminating in increasing the time propagation delay.





Related Works

Liang et al. [1] formulated the RSUs deployment problem as an integer linear program (ILP) and suggested a particular configuration for every individual RSU to satisfy a certain coverage requirement.

Authors in [2] proposed an optimized RSU placement for delay sensitive application in VANETs. Besides deployment cost constraint, authors' objective was to find the optimal position of RSUs while respecting the application delay constraint.

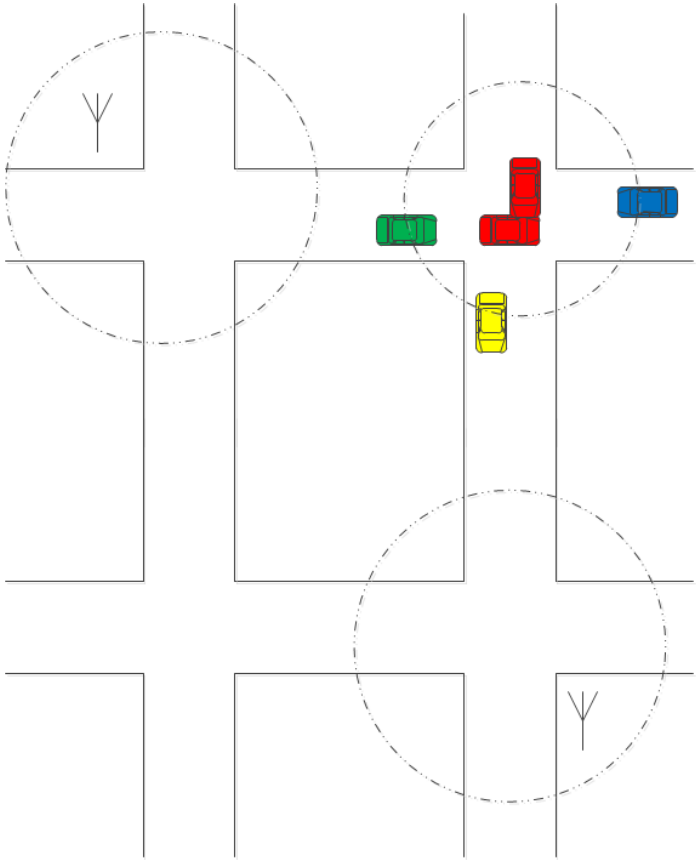
Another study by [3] also addressed the optimal placement of RSUs along highways in order to minimize the average reporting time taken for a vehicle to report an event to the nearby RSU.

Research Problem

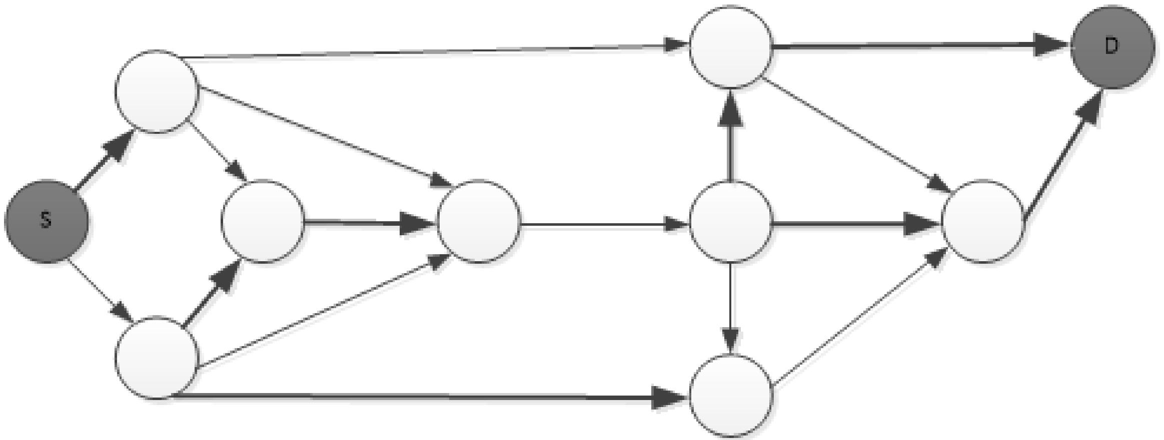
Accident occurs and the disabled vehicles cannot report the incident to the nearest RSU.

The disabled vehicles must report to another vehicle so that it can be relayed to a RSU.

We propose using a vehicle's GPS destination, velocity, and distance to the nearest RSU to select the best candidate vehicle to disseminate the accident report.



Research Problem



The problem can be thought of simply as how best to send data from one disconnected part of an ad-hoc networks to another. We assume the movement patterns of the nodes within the environment is known.

Objectives

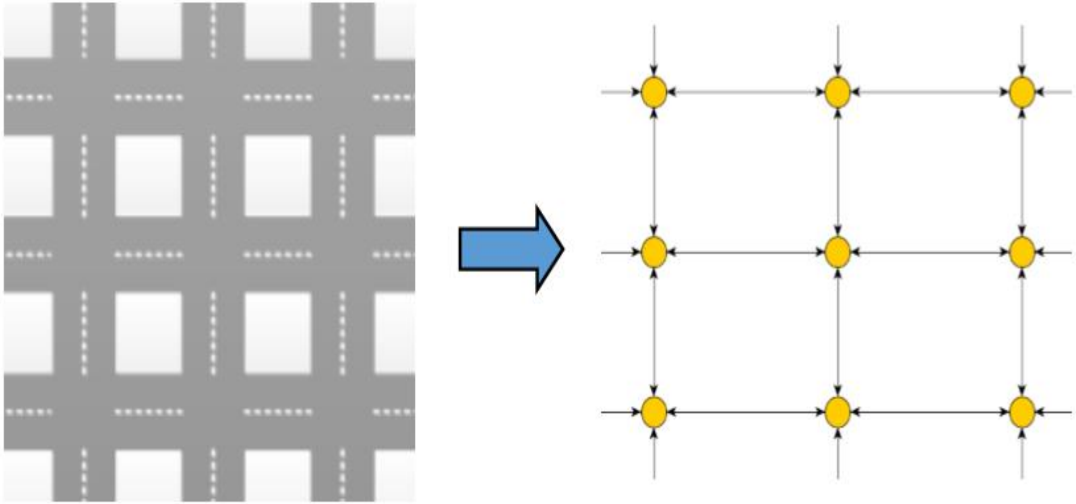
As mentioned earlier, apart from the optimal placement of RSUs within the road networks, optimal selection of disseminating vehicles to report an incident to a nearby RSU is extremely important. Therefore, this motivates us to study an optimal selection of a disseminator through which the overall performance of the dissemination of post-crash warning will be dramatically improved. In what follows, the chief contributions of this study are delineated.

- Identifying a real world problem regarding information dissemination in VANETs with RSU coverage gaps.
- Presenting an approach for selecting the best disseminating vehicle and provide an algorithm to accomplish this goal.
- Using simulation study to assess and validate the performance of our proposed approach under various traffic scenarios.

System Modeling

Streets and intersections are represented as edges and nodes in a graph.

Each lane is one directed edge.



Model Parameters

Symbol	Notation
ΔX	Length of an edge
λ_a	Average vehicle arrival rate (per unit time)
λ_d	Average vehicle departure rate (per unit time)
ρ	Traffic Intensity
V_x	Vehicle velocity at point X

Each vehicle in the network has certain information about the road system.

Traffic intensity, ρ, is equal to λ_a / λ_d.

A traffic intensity greater than 1 indicates traffic congestion. An intensity less than 1 means traffic easing.

Each vehicle knows its current speed.

GPS

It is assumed that all vehicles have knowledge of their intended route.

- ✓ This might seem unrealistic but over 96% of new vehicle have a GPS radio whether they are equipped with a navigation system [1].
- ✓ Destination prediction algorithms exist and are quite accurate [2][3].

Each vehicle will be able to provide a set of edges between its current location and the first RSU on its intended route.

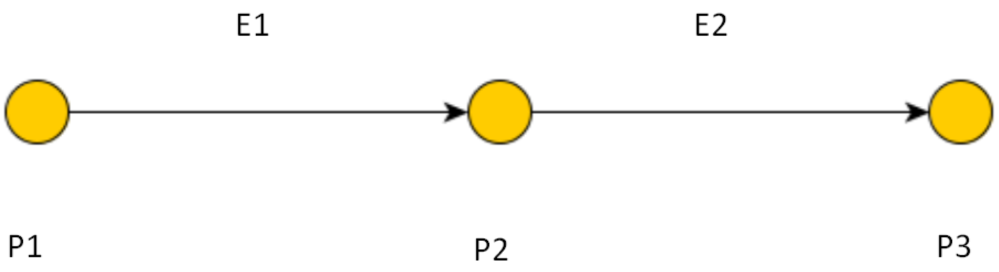
Method for Choosing the efficient Disseminator

Our method uses current velocity and traffic intensity to predict the vehicle’s velocity at subsequent intersections.

The average velocity across an edge is used, along with the edges length, to calculate the time it would take to traverse the edge.

This is repeated on subsequent edges to determine the time to traverse the set of edges between the current location and the nearest RSU.

Calculations



$$V_1 = Initial\ Velocity$$

$$V_2 = \frac{V_1}{\rho_1} \quad \text{and} \quad V_3 = \frac{V_2}{\rho_2}$$

$$\Delta T_1 = \frac{\Delta X_1}{\frac{V_1 + V_2}{2}} \quad \text{and} \quad \Delta T_2 = \frac{\Delta X_2}{\frac{V_2 + V_3}{2}}$$

Algorithm

Algorithm 1 algorithm for calculating total travel time between current location and RSU

Input:

A set of edges, e[], between the current location and the closest RSU

The vehicle's current velocity, initVel

The sets containing edge arrival and departure rates for each edge, lamdaA[] and lamdaD[]

The set of edge lengths, deltaX[]

Output:

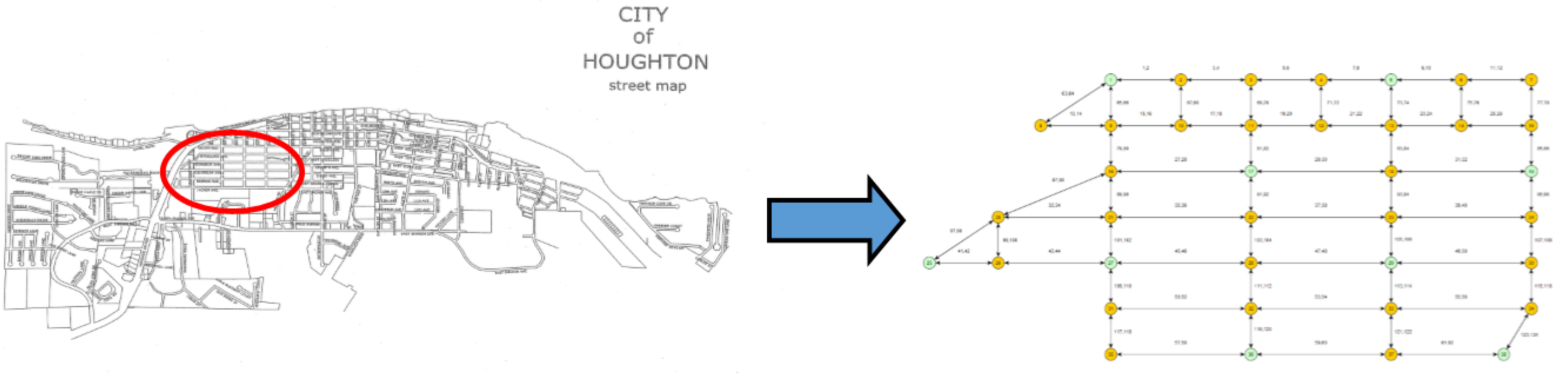
The total time to traverse the set of edges

```
1. vel[0] =initVel
2. for i=1 to i=length(e[])
3.         vel[i]=vel[i-1] * lamdaD[e[n]] / lamdaA[e[n]]
4. end for
5. for j=0 to j=length(e[])
6.         time[j]=2*deltaX[e[n]]/(vel[n]+vel[n+1])
7. end for
8. return sum(time[])
```

Simulation

To show the superiority of the proposed method we ran a brief simulation, comparing the results against two other potential methods.

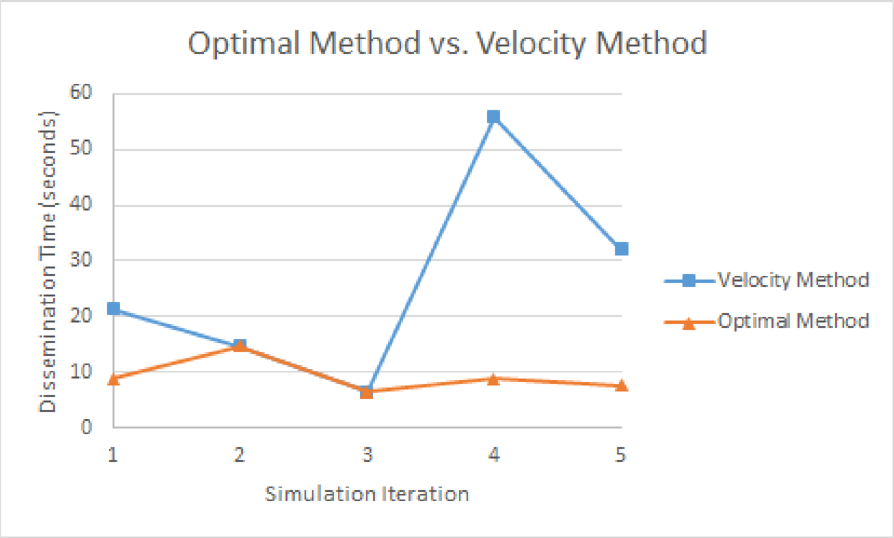
1. Velocity Method, choosing the vehicle with the greatest current velocity.
2. Distance Method, choosing the vehicle with the shortest distance to a RSU.



Simulation Parameters

- RSUs were located throughout the map in mesh pattern.
- Location of an accident was selected.
- A random number of potential disseminating vehicles were identified each with a random travel route.
- Each was given a random initial velocity between between 9 and 14 m/s (20 and 30 MPH)
- 5 iterations were run.

Results



Our method outperformed the Velocity Method in 60% of the simulation runs.

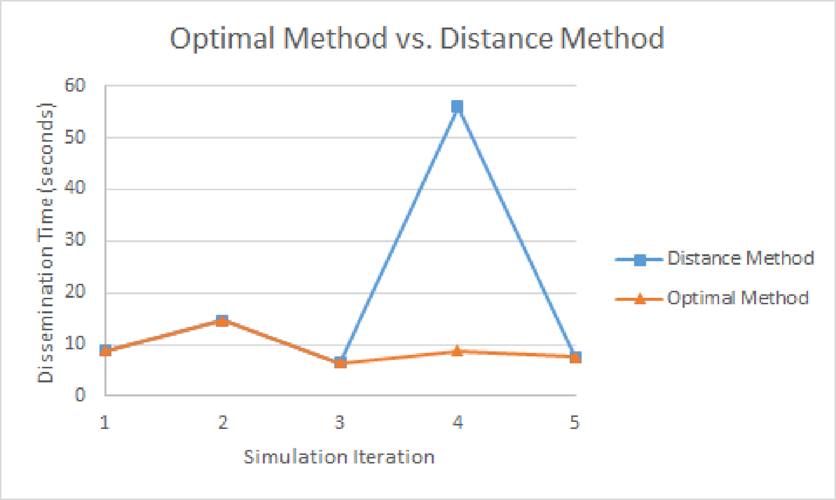
When it didn't outperform it performed equally as well.

Average decrease in propagation time by 43.8%.

Results

Our method outperformed the Distance Method in only 20% of the simulation runs.

On average, propagation times decreased by 16.86%.



Conclusion

In this study, we proposed an algorithm through which the best vehicle to deliver the post-crash warning message in the shortest amount of time is selected. This allows surrounding vehicles to be informed about the accident in a timely fashion, avoiding traffic congestion and/or secondary accident.

Our proposed approach is validated through simulation study under different traffic scenarios and successfully outperforms the existing solution in terms of average propagation time of the warning message.

References

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