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Optimization of Emergency Response System Using Cellular Network

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Abstract: *VANET is a specific class of Ad-hoc network. Applications of VANET vary from safety applications like warning signals, keeping safe distance among vehicles to non-safety applications like traffic congestion, route information, Internet access. Timely help in emergencies like fire, medical etc. is of utmost importance. Response time can be reduced if Emergency Response Vehicle (ERV) can be routed through city roads such that minimal time is taken. We focus on estimating traffic on the roads so that optimum route in terms of time taken can be found. We aim to do it without modifying/adding any infrastructure. Nowadays, almost every person while travelling carries mobile phones. If location of these phones can be traced then traffic can be estimated. There are many localization techniques which are useful to give accurate location information of any Mobile Node like GPS, dead reckoning, Cellular networks. But, penetration of GPS enabled phones with active GPS is very less. So, this paper aims to estimate traffic using cellular networks, which uses in-built infrastructure and is cost effective. From traffic estimates and length of the routes, optimal route is chosen using a unique formula.*
Keywords: *Emergency Response System, Ad hoc networks, Localization, GPS, Cellular Network*

I. Introduction

At present day, vehicles and vehicular activities have increased immensely which have captured researchers' interest. VANET is a specific domain of MANET. It is distributed, self organizing and not fully centralized unlike traditional networks. Vehicles communicate with each other either vehicle to vehicle (V2V) or vehicle to road side infrastructure(V2I). With the increase in number of vehicles, applications are expected to be managed properly which reduces hazardous condition, traffic jams or random stops which can be achieved by proper communicating medium, robust and efficient system. Also, in many applications, vehicle’s position or traffic condition is made known to other vehicles or the system managing those vehicles. From that information, overall network topology is known which helps in diverting vehicles through other routes, traffic jams conditions, critical incidents.There are many techniques like GPS, dead reckoning, cellular networks etc. which can measure location of Mobile Node (MN) accurately. Amongst them, locating MN through Cellular Networks (CN) has advantages as it uses already built-in infrastructure which reduces implementation cost and time compared to the system where additional devices are needed. The remainder of this paper is organized as follows. In section II, we show how positions can be computed through several localization techniques. Section III, is a proposed scheme in which it is explained how traffic data is generated, traced depicting CN model and vehicle is routed to less congested and shortest path. Section IV shows simulation results. Finally, section V discusses conclusion and future work.

II. Localization Techniques

To trace traffic, we need to locate cell phone position which is initial and crucial task. There are some challenges to find exact location of MN. Due to the factors like topology, area, infrastructure. No technique works to its optimum. We analyze different models for finding location of MN and and their performance one by one.

2.1 Global Positioning System (GPS)

GPS, the Global Positioning System, is composed of 24 satellites which can operate in orbit around the earth in a such a way that they falls in a line of sight of GPS receiver. To locate the position of MN, vehicle must be equipped with GPS handset. On a request to find location, GPS handset will calculate the longitude, latitude and altitude information based on satellite broadcast. Accuracy is high to locate node using GPS. However, these signals are blocked by obstacles including buildings, electronic interference, rocks etc. In dense urban areas, tunnels, indoor parking lots, forests, position is not calculated accurately. Moreover, GPS installation is a bit costly technique. Not all vehicles are GPS equipped and also not all the users carry GPS enabled mobile phones in vehicle.

Fig 1. Locating using Three satellites-GPS [1]

2.2 Dead Reckoning

By using Dead Reckoning [2], the current position of a vehicle can be computed based on its last known location and using such movement information as direction, speed, acceleration, distance, time, etc. The last known position, also known as a fix, can be obtained, for instance, by using GPS receivers (which are most common) or by locating a known reference (road crossing, parking lots, home, etc) on a digital map. In practical VANET, Dead Reckoning can be used only for short periods of GPS unavailability, or be combined with Map Knowledge.

2.3 Cellular Networks

2.3.1 Cell Identity (Cell-ID)

As referred from [3], This is the simplest form of positioning technology, and is network centric. The mobile network always knows the location of a registered mobile handset to location area level, and when a call is in progress it knows which of the cells within the area that is communicating with that handset. The cell centre is used as an estimate for user location. The cell size will obviously define the resolution. Hence the accuracy level for GSM 1800 (where cell sizes are smaller) is better than accuracy level compared with GSM 900. The 3rd Generation of mobile phones, UMTS, will obviously provide better results than GSM 1800 since it operates at 2000 MHz and has smaller cell size. Locating MN is three phase process: In the first phase, the coordinates of the serving cell are required. In the second phase, an approximate distance of the MS to the centre of the cell will be required. Then, finally in the third phase, the location of MS must be provided with certain accuracy. The serving cell information alone is sufficient location information to fulfil the phase 1 requirements. In urban areas where pico or nano cells are used, it may be sufficient to just know the serving cell even in phase 3. Also, in high buildings where one cell serves only a few floors, cell identification provides an easy way to provide altitude information that is difficult to obtain in other ways

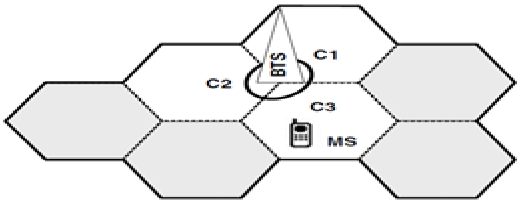

Fig 2. Locating using cell-id [4]

2.3.2 Angle Of Arrival(AOA)

As referred from [5],This involves measuring the angle of arrival of a signal from a base station at a mobile telephone or the AOA of a signal from a mobile telephone at a base station. In either case, a single measurement produces a straight line locus from the base station to the mobile telephone. Another AOA measurement will yield a second straight line, the intersection of the two lines giving a position fix for this angle-angle system. In this case, there is no ambiguity, because two straight lines can only intersect at one point.

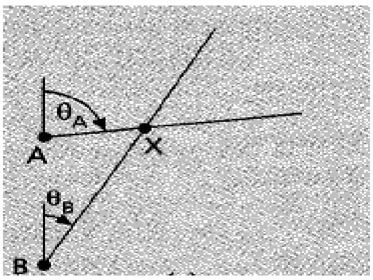

Fig 3. Angle of Arrival (AOA) [5]

2.3.3 Time of Arrival (TOA)

TOA [5] [3] positioning technique measures time delay of signal from mobile device to serving BTS. Location information thus retrieved from LMU, is co-located with base stations. This technology works on any handset. No extra changes required. Combining the calculated signals from all the base station, position of node can be know by applying triangulation method.

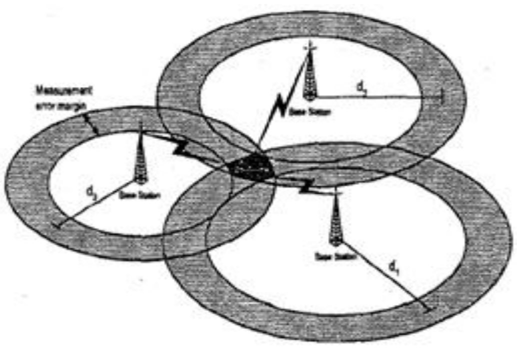

Fig. 4: Time of Arrival (TOA) [3]

III. The Proposed Scheme

Proposed Scheme is divided in total 3 sections, namely, Vehicle Plotting Using SUMO, Depicting scenario as CN, Finding Shortest Path. Following sub-sections will explain each one in detail.

3.1 Vehicle Plotting Using SUMO.

As data from Cellular Providers is not available, therefore, we generated cell/sector membership information of mobiles and their approximate distance from cell tower using VANET mobility models, SUMO/MOVE.

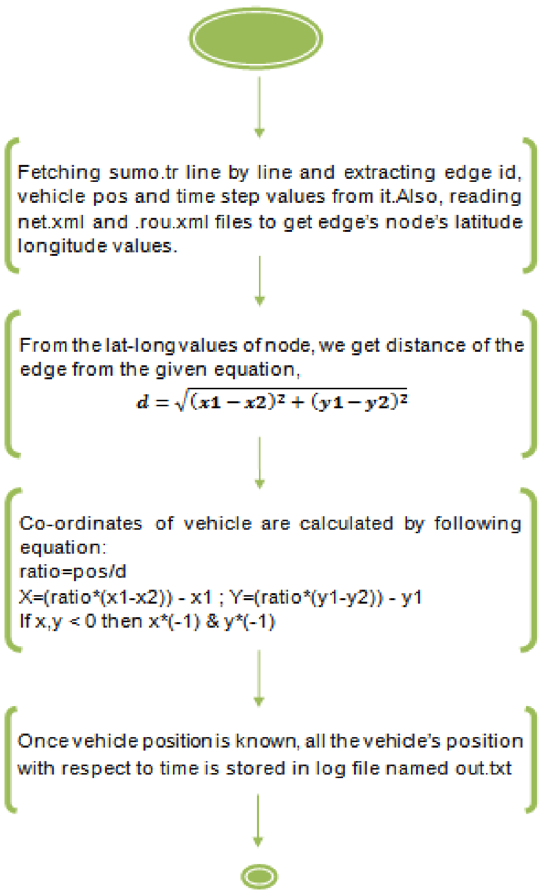

Fig 5. Flow chart showing Vehicle plotting using SUMO and its files

3.2 Depicting Scenario as CN.

To depict similar scenario as CN, in this section it is shown that whole map area is divided into hexagonal cells. Further, each cell is divided into 3 sectors. As one of the techniques to locate MN is TOA which calculates delay in the signal from MN to BTS. Thus, using that delay, it is possible to find distance of MN from BTS. This scenario is modelled here and distance of vehicle from centre of cell is calculated. There are various nodes which can either be moving or static. So, only those nodes are considered which changes hexagon or sector with respect to time and rest of the static nodes are not considered for that time. Furthermore, whole map is super-imposed on this hexagonal region. Intersection of edges to the hexagon and sector is logged into file. As it is shown in flow chart, when vehicle and edges distance matches from centre of the hexagon, that vehicle is considered to be moving on that edge. So, total vehicle count of that edge is incremented. Flow to find total number of vehicle on the edges at a given time is shown below given flow chart.

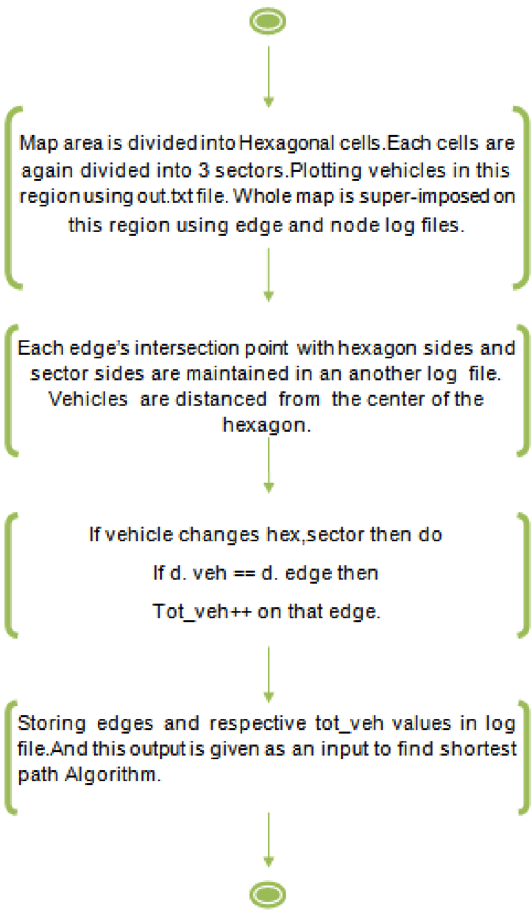

Fig 6. Flow chart depicting scenario as CN

3.3 Finding Shortest Path

After getting total number of vehicles on the edges/road, task is to find shortest and less congested route. Therefore, Dijkstra is used with different cost metrics which considers both distance and traffic to estimate total time required to traverse from source to destination which is given by the equation,

$$d = d + \alpha * tot\_veh * d \qquad (1)$$

Finally, total time a vehicle takes to traverse whole route is given by,

$$t = d/speed \qquad (2)$$

Where, d = distance between two nodes.
Tot_veh = total number of vehicle on that lane.
speed = a maximum speed a lane can allow.
t = is a total time required by a vehicle to traverse.

α = is a tuning parameter.

Source and destination nodes are given as an input and below given flow is used to calculate shortest and less congested path between those two nodes.

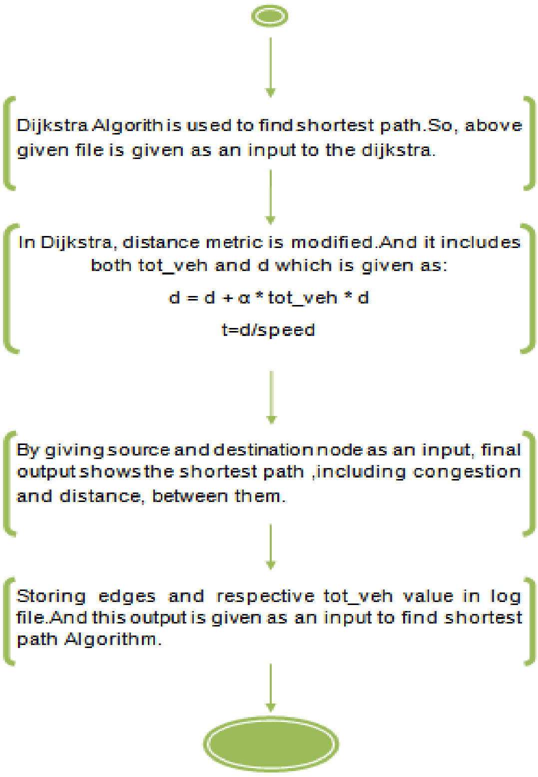

Fig 7. Flow chart showing Dijkstra algorithm

IV. Analysis And Results

To compare proposed algorithm with traditional shortest path based on length of the route only, two paths have been considered. Here, source node and destination node taken as 16 and 4 respectively.
Route1[16-12-8-4]: It is obtained by applying simple dijkstra without considering any traffic
Route2[16-15-6-5-4]: It is obtained while applying proposed algorithm considering traffic on network.

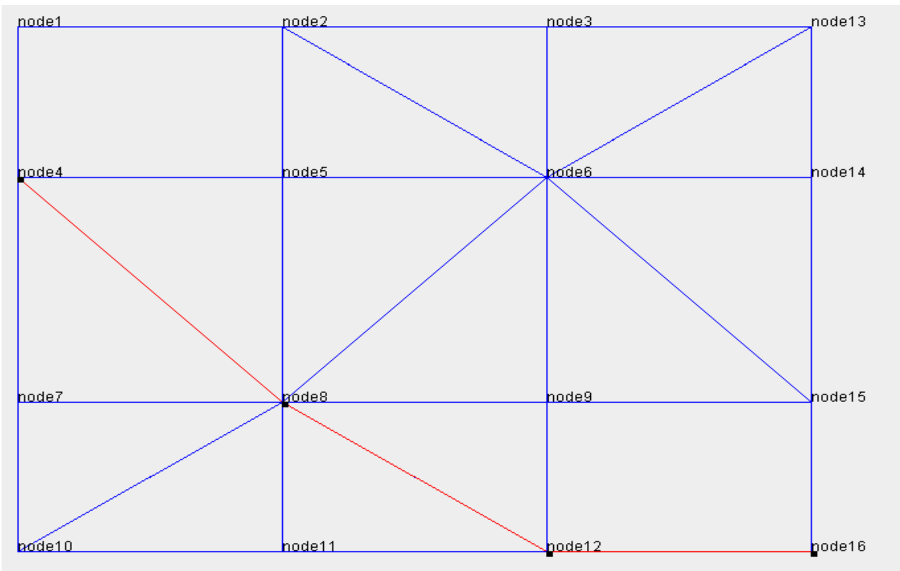

Fig 8. Route1

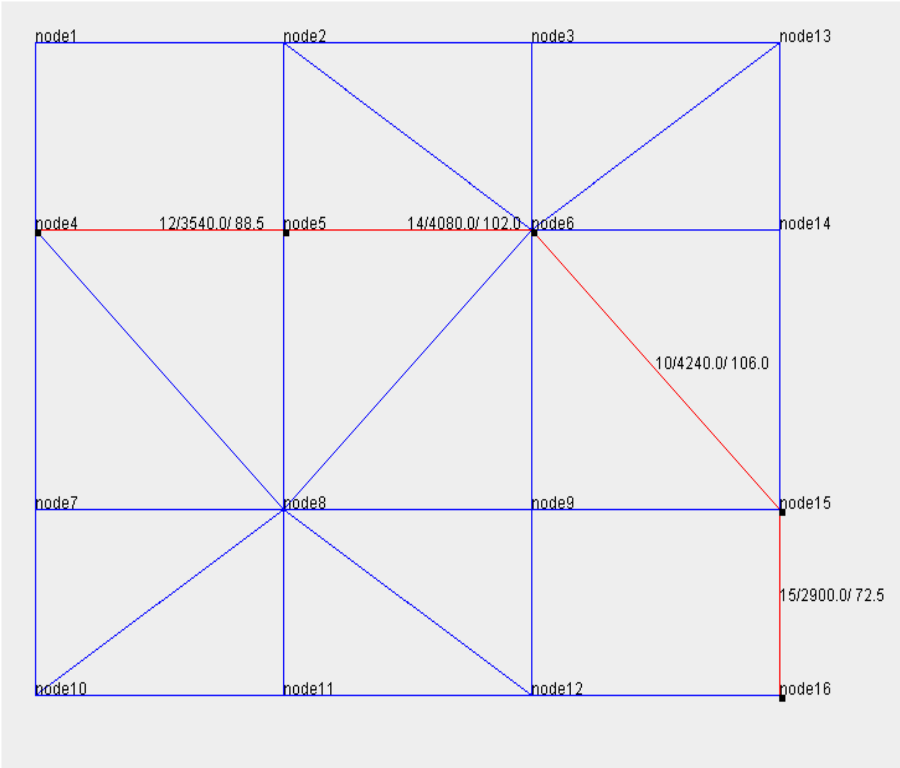

Fig 9. Route2

Below given simulation runs are done considering different average traffic of 25, 60, 75 and 100. Tables shows actual time taken for a vehicle to traverse on a given route1 and route2. As route1 is shortest without considering traffic. Now, to compare performance of proposed algorithm, different a values are considered. Value of α = 0.9 in Eq. (1) gives estimated time closer to time taken in simulation for route2 irrespective of different traffic conditions.

TABLE I: Analysis for Traffic = 25

Route	Simulation Time (Sec)	Proposed Algorithm Time(Sec)			
		α=0.95	α=0.9	α=0.8	α=0.7
Route1	773	-	-	-	-
Route2	406	387.9	369	331.4	293.8

TABLE II: Analysis for Traffic = 60

Route	Simulation Time (Sec)	Proposed Algorithm Time(Sec)			
		α=0.95	α=0.9	α=0.8	α=0.7
Route1	1584	-	-	-	-
Route2	1091	1157.76	1098.45	979.8	861.15

TABLE III: Analysis for Traffic = 75

Route	Simulation Time (Sec)	Proposed Algorithm Time(Sec)			
		α=0.95	α=0.9	α=0.8	α=0.7
Route1	1819	-	-	-	-
Route2	1558	1734.33	1644.66	1465.32	1285.98

TABLE IV: Analysis for Traffic = 100

Route	Simulation Time (Sec)	Proposed Algorithm Time(Sec)			
		α=0.95	α=0.9	α=0.8	α=0.7
Route1	2410	-	-	-	-
Route2	2209	2306.52	2186.73	1947	1707

TABLE V: Comparison of Route1 and Route2 simulation time

Routes	Traffic= 25	Traffic= 60	Traffic= 75	Traffic= 100
Time taken for shortest path without traffic consideration	773	1584	1819	2410
Time taken for Proposed algorithm With traffic consideration	406	1091	1558	2209

As shown graphically in fig 10, though route1 is shortest but when it is congested, travelling through that route takes more time while route2 is longer in distance but due to less traffic on road, time taken to traverse is less.

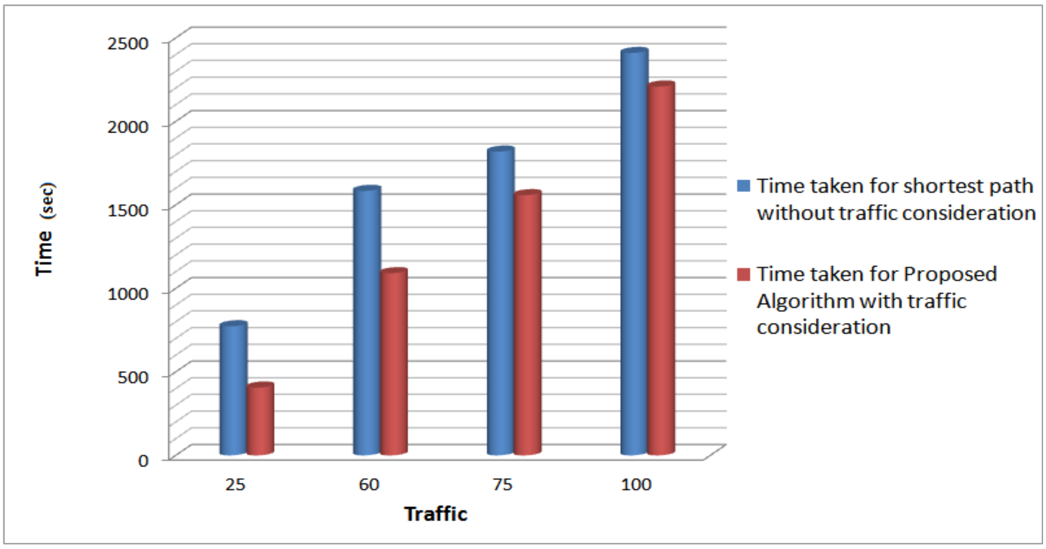

Figure 10. Results comparing proposed algorithm with traditional shortest path approach

V. Conclusion And Future Work

In this paper, Cellular Network technique is used to locate MN. So ,traffic estimation has been done using CN. Also, Dijkstra is used with different cost metrics which considers both distance and traffic to estimate total time required to traverse from source to destination. Moreover, from the results shown in tables of different average traffic, it has been shown that value of α= 0.9 is preferable which gives time value closer to the simulation. Furthermore, as simulation results suggest, our scheme finds optimum path in terms of time taken in the presence of varied degree of traffic on the path.

In CN, accuracy of locating MN is low which opens the scope to optimize the technique and locate MN more accurately. Furthermore, the system can be extended with integrated traffic signalling unit and GPS which manages traffic signals at the intersection on the way of ERV such that when ERV approaches the cross road, signal turns green beforehand.

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