Relative Location Determination In Vehicular Ad-Hoc Networks

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Abstract: Relative location determination in Vehicular Ad Hoc Networks (VANET) is a field of location studies, that researches the exchange of location between vehicles and gives a service for end users to help them, this thesis suggests a new approach for VANET to exchange the location without using Global Positioning System (GPS) map or Roadside Units (RSU), by exchanging the location between vehicles that already have location and update their location or update other vehicles' location. Other approaches work on GPS and/or RSUs to exchange the location and give the location to the vehicle, but the accuracy of the GPS is not good in some areas or places and some roads have not been equipped with RSUs. The suggested approach consists of three cases; the first case is when a vehicle loses a GPS signal, the second case is to start looking for the location in an area with no GPS coverage, and the last case is the low accuracy of GPS location data. Using this approach will introduce a hybrid system that can give the users many ways to get an accurate location and exchange their location with other vehicles. It can also be utilized for many services that will help companies and service providers. The result confirm that the system can add values to the accuracy with more than 3% from the average of the system of the accuracy that the system have already started with and we can transfer the location data to more than 95% of total nodes.

Index Terms: VANET , GPS, location, (RSU).

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1 Introduction

So many mobile nodes do not know their current location, but they may need it for choosing a route and calculating the distance to other locations, but if the GPS is not available for some reason, a node may need to calculate its relative location according to the nearest node that has its location coordinates. Location can be calculated in two cases, the first case is when a node gets lost in the road and can't find its current location, in this case the node will search for nearest node that has its location coordinates and then calculate its relative location to the reference node. The second case is when a node has no location and cannot find a nearest node with location coordinates then the node will have to work on calculating its own distance depending on the node's movement and direction, where the reference will be the last known location [1]. Using GPS to get the accurate physical location is not applicable in all environments because in some cases, the location provider is offline or there is no coverage for that physical location [2]. To get accurate locations along the path from source to destination using GPS and well-known map direction using any map application like Google maps, the way from source to destination must be well covered and the terminal must be ready to read accurate GPS regardless of the environment [3]. In modern times the location based service applications are getting involved in our daily lives, providing an accurate physical location such as GPS in all environments is not always applicable because in some cases, there could be no coverage of physical location support, so the main goal is to find a relative location from the nearest node and get a flexible system to give the vehicles their location to get back on the right path. With nodes having high speed the location packet should arrive correctly to the requested node.

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This proposed study aims at to produce a more Relative Location Determination application that can give the better performance for GPS location determination over VANET communication between vehicles.

2 Related Studies

In this section, we present some related research to mobility models in Ad-hoc networks. In [4] they introduce A Localization Algorithm Based on V2I Communications and angle of arrival (AOA), this approach uses a massage received from RSUs and aims to obtain an angle of arrival from this message, this data is used by the algorithm to position the nodes, and the method tries to take characteristic of multi measurements from multi RSUs for more realistic data to give an accurate location and the result of the algorithm shows the effectiveness of it. In [5] they present a Position Prediction based Multicast Routing (PPMR) using Kalman Filter on Vehicle AdHoc Network, they use a unicast protocol and Position Prediction based Unicast Routing (PPUR) for applying the PPMR and by GPS position and Inertial Navigation System (INS) also installs maps on the nodes to collect the location data from the nodes to formalize the clusters, each node has location and mobility information, every source-destination route help the destination node to build a path prediction. If the route is broken the prediction done by the destination node without using any route recovery, they using Kalman Filter (KF) to remove any wrong position data that uses the distance between nodes. This algorithm helps to reduce the broadcast problem and minimizes the route discovery latency. In [6] they determined the relative position of vehicles considering bidirectional traffic scenarios in VANETS, by using traditional GPS data and the help of image processing applications to get a location to the nodes, and the workout result shows that they can use GPS error and image processing application can get more accurate data. In [7] they present roadside unit (RSU) and in-vehicle inertial navigation system(INS) helped for localization system for GPS-challenged road segments, the cars need RSU in their range to get an accurate location, the data that arrives form RSU and INS are used to obtains particular circle areas, and the system uses the linear least square estimation technique to get the car directions , the system tires to collect an enough circle area to minimize the localization error. In [8] they propose a novel approach for improved vehicular positioning using cooperative map matching and dynamic base station DGPS concept this approach has two steps the first one is map matching that uses “node to node” communication in VANET network and exchanges the GPS data between each other, the second step is to use dynamic base station DGPS (DDGPS) to broadcast GPS correction by the arrived nodes. The performance of the method has been verified with simulations in several scenarios. In [9] they present an Implementation of On-Board Diagnostic and GPS on VANET to Safe the Vehicle , they use intravehicular and V2v communication to enable the safety of vehicles , and they connected the vehicle with OBD system to save the vehicle information in it , and equipped with IPAD that has an offline maps to show the real time GPS information and by using a system to exchange the data between the vehicles, and using LET remote servers to monitor the vehicles and the data that is exchanged between other. The second idea discusses the network model used and problem definition in VANETs, the vehicles are equipped with Application Unit (AU) and an On Board Unit (OBU) that are responsible for vehicle communication, and RSUs are installed alongside the rode and act as service provider and the vehicles equipped with AU and OBU as clients to access these service, AU and ORU may be a single unit or may be a separate unit. The proposed Idea is a concatenation between them to get a flexible system in any area that the vehicles are in [10]. In [11] they have introduced Improving positioning accuracy for VANET in real city environments , the architecture proposed is called cooperative positioning via dead reckoning (CPDR), that uses I an improving Positioning in real city environments (IPC) algorithm to get more accurate position for the vehicles, the IPC algorithm work on vehicles that are equipped with a GPS receiver, and it should be at least two vehicles on the same road to contact between each other to calculate the accurate position or to re-correct the position. In [12] they describe the message transmission and critical problems of safe driving in VANET, the vehicles collect the information from the traffic and road situation to avoid accidents on the roads. The vehicles that are close to the accident receive real time emergency messages; the information is exchanged between neighboring vehicles via V2V or RSU. In [13] they describe the deployment an algorithm to cluster the nodes and fully distribute them, by dividing the network into clusters where vehicles with high mobility are in one group and vehicles with low mobility are in another group, then they deploy an algorithm to select a node as a cluster head for the groups. With periodic messaging the nodes will build their neighborhood relationship, and the clusters will be formed by the direction and speed of the vehicles, and the vehicles are required to classify their neighbors.

3 METHODOLOGY

As demonstrated in this document,
This section demonstrates the methodology of the proposed work that focuses on vehicles that lose their location and want to get the location of nearby vehicles using WIFI signals, so the main goal is to find the relative location from the nearest node and get a flexible system to give the vehicles their location to get back on the correct path. The methodology of our system is based in the following points:

- All random number have been generated using MATLAB (rand) function.
- Checking for data happened internally inside cars.
- If cars have no location, it will start looking for other cars location broadcasting.
- If car have accuracy less than threshold it should also start looking for other cars location broadcasting with better accuracy, accuracy differences calculated by subscribing the new over the old accuracy, if results come in positive new location will be taken, otherwise car will maintain their old data.
- The ratio of car that have gained the location data that have been used on measuring our system functionality calculated as following:
  ROV=(B-C)/A
  A = #car without location before system start
  B = #car with location after system start
  C = #car that already have the location before system start
- The added accuracy that have been gained and we used on measuring our system functionality calculated as following:
  AAR=AA-AB
  AAR = Added accuracy ratio.
  AB = Average of accuracy for all car with location data before system start.
  AA = Average of accuracy for all car with location data after system finish.

Point 5 and 6 calculated after averaging 1000 iteration in order to make the system readings more accurate.

4 PROPOSED WORK

This section describes the working methodology as shown in above as following:

1 If the vehicle does not have a GPS location, it looks for a vehicle with a location, and then it tries to find vehicle with a location.
2 If it finds a vehicle with a location, it will check the accuracy of the location.
3 If the error ratio for the location is low the car will broadcast the location to other vehicles by its location and other location that the car get.
4 And if the error ratio is high the vehicle will look for new vehicle with a lower error ratio and broadcast it to others.

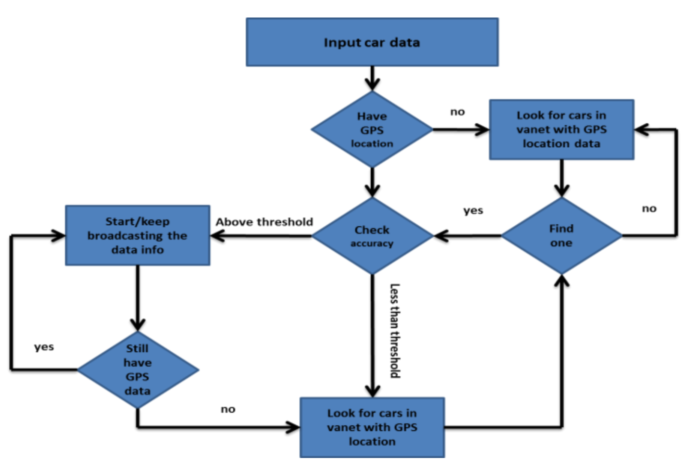

Figure 1: *our working methodology*

1.1. Case of use

This section talks about where the system can be implemented and used, our system has three cases, the first one is when a vehicle loses a GPS signal, and the second case is to start looking for the location in an area with no GPS coverage, and the last case is the low accuracy for GPS location data.

- Loosing GPS Signal
- No GPS signal
- Low Accuracy

1.2. The effecting factors

This section describes the factors that have effect on the location in VANET networks, as already discussed, vehicle Ad-Hoc network is a collection of vehicles with high mobility so when trying to connect to others and exchange their location, there are several factors that may affect the process of acquiring an accurate location and there are factors that can help acquiring the best accurate location, so this section demonstrates some of these factors.

- Cars Density
- Road speed limits
- Connecting radius

5 Results

All the results of the following 5 study cases will represent the relation between the 2 main fixed factors in comparison with the 5 case of study parameters, accuracy enhanced in average which represents the accuracy difference average before using our system and after using it and the second one is the average of cars that had the location using our system and will be represented by the ratio between the number of cars that didn't have the location before the system starts and the number of vehicles that have it after using the system.

5.1. Case 1: Number of Vehicles

The first case of study is measuring the effect of changing the number of vehicles on the roads, and how the change on the vehicle's number can affect the average ratio of accuracy or the average ratio of the cars that can use the location data determined using VANET, figures 2 and 3 show the results of this factor analysis.

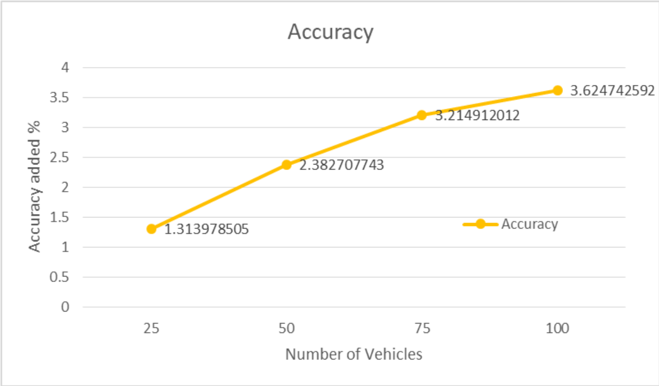

Figure 2: *Number of vehicles affection in accuracy added ratio*

Figure 2 shows the increasing of "accuracy added ratio" as the number of vehicles in our network increase. these results caused by the increasing of available nodes that can take, hold, distribute and re-distribute the location data, and the more nodes there is, the density among the VANET will increase and the connectivity will increase too, and as we described in our methodology, the nodes will keep searching for better and more accurate location data as long as the accuracy is less than a predefined specified value.

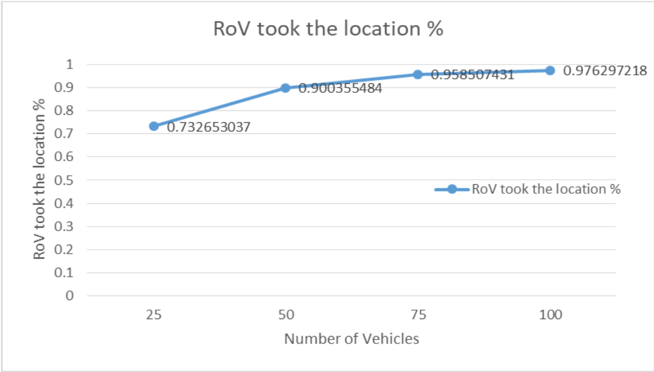

Figure 3: *Number of vehicles affection in RoV that took the location*

Figure 3 shows the increasing Ratio of Vehicles (RoV) that have took the location data, and as this ratio describe the ratio between the cars that have started in our system without location data or lost it on the way and the cars that have used our system to have the location data, the results shows great increase by almost 18% when the number of car changed from 25 to 50 this trending up decrease its rising slope when we change the NoV to 75 to add only 5% to the value of our system and the other increase from 75 to 100 show less increasing by almost 2.5%, this change in trend lead us to believe that the critical ratio between NoV and road length can be determined by dividing 10000 m on 50 cars which will equal one car to each 200 meter is the critical threshold for VANET network location data exchange system.

5.2. Case 2: Road Length

The second case of study is measuring the effect of changing the road length, and how the change on road length can affect the average ratio of accuracy or the average ration of the car that can use the location data determination using VANET, figures 4 and 5 show the results of this factor analysis.

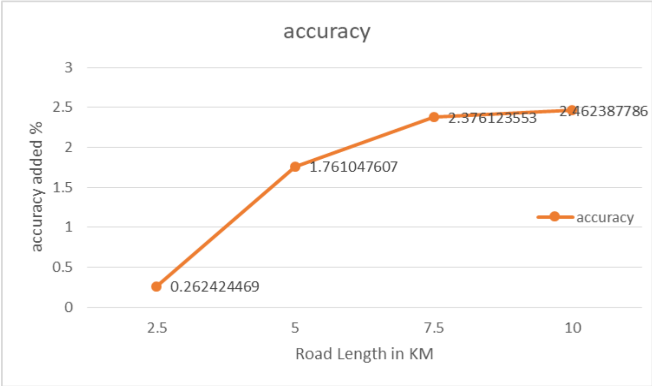

Figure 4: *road length affection in accuracy added ratio*

Figure 4 shows the increasing of accuracy added ratio as the road length in our network are increasing, this results caused by the increasing of the time of the network which lead to increase the time of staying in the networks and increase the chances of nodes intersections as speed between nodes are variant, the results shows that 7.5 Km is the best fitting length for the road with respect to our system other factors.

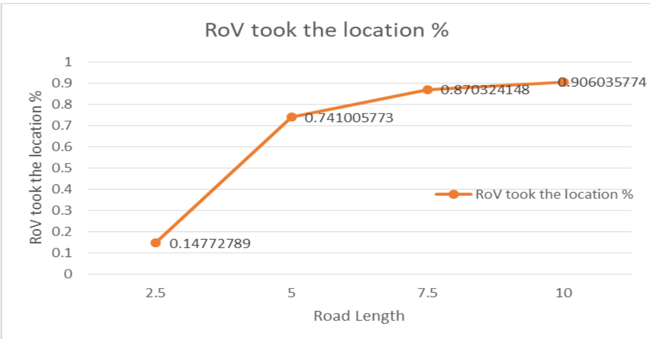

Figure 5: *road length affection RoV that took the location*

Figure 5 shows the increasing in Ratio of Vehicles (RoV) that have took the location data, and as this ratio describes the ratio between the car that have started in our system without location data or lost it in the way and the car that have used our system to have the location data, the results show that almost 15% only took the location data, which mean that with short distance the system is not giving high performance, but when the road length changed from 2.5 to 5.0 Km the trending up slope raised sharply to 74%, and then to 87% and 90% when we change the length to 7.5 and 10 respectively, which indicate that our system critical road length is around 5 Km.

5.3. Case 3: Vehicles Speed Variance

The third case of study is measuring the effect of changing the speed limit variance between lanes of the roads, and how the change on speed limit variance can affect the average ratio of accuracy or the average ratio of the cars that can use location data determination using VANET, figures 6 and 7 show the results of this factor analysis.

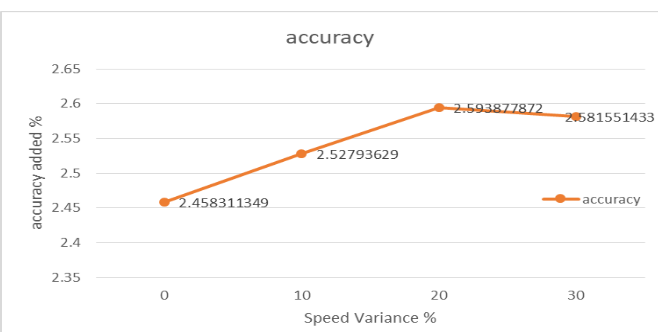

Figure 6: *speed limit variance affection in accuracy added ratio*

Figure 6 shows the increase of accuracy added ratio as the speed limit variance in our network is increasing, this results caused by increasing of the available nodes that can take, hold, distribute and re-distribute the location data, and the more nodes we have with different speed the more data stations we have, this will lead us to a better performance, this process will keep raising up the gained accuracy until the system reach the critical limit of 20% variance between nodes, because after that the value will start to drop as there is very high speed variance between node the time of intersections or the time of connecting between nodes will not be enough for data transfer, which will lead to less accuracy added value as we moved on in increasing the speed variance between nodes.

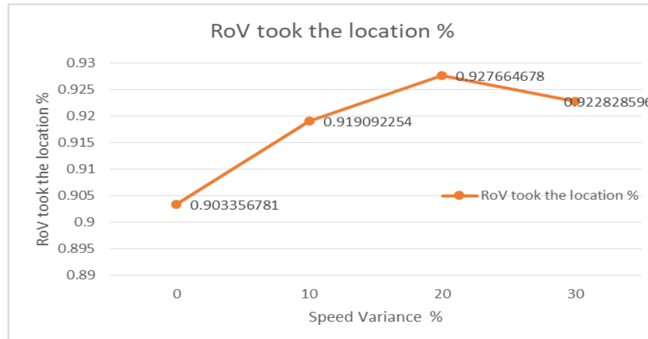

Figure 7: *speed limit variance affection in RoV that took the location*

Figure 7 shows the increasing Ratio of Vehicles (RoV) that have took the location data, and this ratio describes the ratio between the car that has started in our system without location data or lost it on the way and the car that has used our system to have the location data, the results show good results by almost 92% when the speed variance reaches the 20% but after that it starts to drop again after that which, for the same reason we have explained in an above paragraph, but we can notice too that the results in all cases of speed variance is more than 90% which means that the variance of speed between lanes is not a major factor and will not hugely effect our system results.

5.4. Case 4: Connection Radius

The forth case of study is measuring the effect of changing connection radius of vehicles among the VANET, and how the change on radius can affect the average ratio of accuracy or the average ratio of the car that can use location data determination using VANET, figures 8 and 9 show the results of this factor analysis.

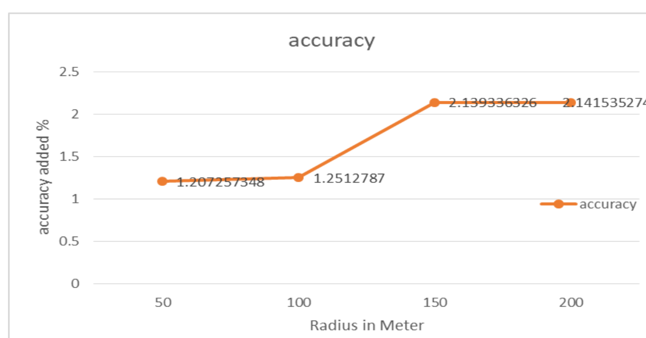

Figure 8: *changing connection radius affection in accuracy added ratio*

Figure 8shows the increasing of accuracy added ratio as the connection radius of nodes in our network are increasing, the graph shows that 150 meter radius is the threshold of our system as it is the place where great changes in accuracy added values happened, but after that, the transition from 150 to 200 didn't add any more values to the system, this happened because 150 meter is the ideal range that the node can cover with it both road side for all lanes and can have enough time to make the connection and take the location data.

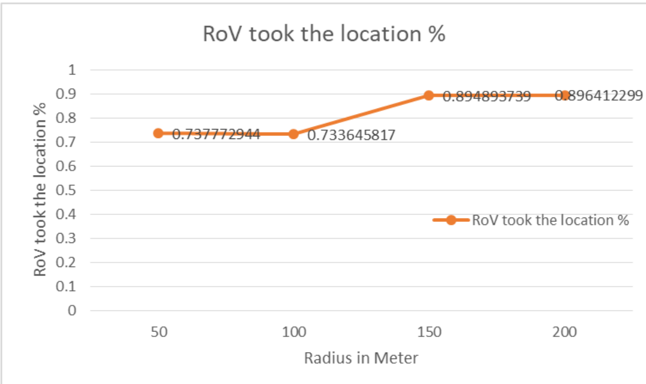

Figure 9: *changing connection radius affection in RoV that took the location*

Figure 9 shows the increase in Ratio of Vehicles (RoV) that have took the location data, and as this ratio describe the ratio between the car that has started in our system without location data or lost it on the way and the car that has used our system to have the location data, the results show almost no increase in connection radius changed from 50 to 100 this trending up increased when we changing the radius to 150 by 16% then it stayed almost constant noticeable changes after we have changed it to 200 meter and this change is caused by the same reason that we have described before, the 150 meter radius is the ideal radius for our system as it can cover both sides with all lanes and gave the sufficient time for connection and data transfer.

5.5. Case 5: Ratio of Vehicles that have Location when the System Start

The first case of study is measuring the effect of changing the Ratio of vehicles that have the location when the system started, and how the change on RoV can affect the average ratio of accuracy or the average ratio of cars that can use location data determination using VANET, figures 10 and 11 show the results of this factor analysis.

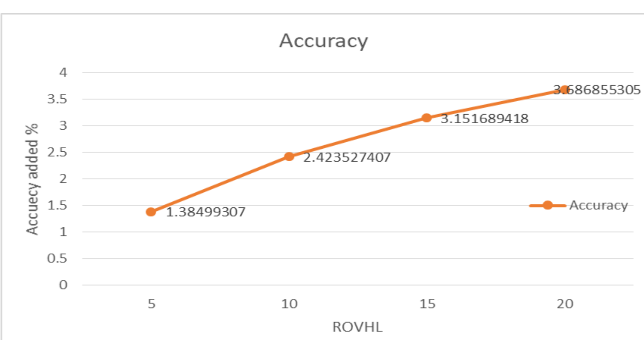

Figure 10: *Ratio of vehicles that have the location affection in accuracy added ratio*

Figure 10 shows the increase in accuracy added ratio as the Ratio of Vehicles that have Location when the System Start in our network are increasing, these results are caused by the increasing of the available nodes that can take, hold, distribute and re-distribute the location data, and the more nodes we have, the density among the VANET will increase and the connectivity will increase too, and as we described in our methodology in chapter 3, the nodes will keep searching for better and more accurate location data as long as the accuracy is less than predefined specified value.

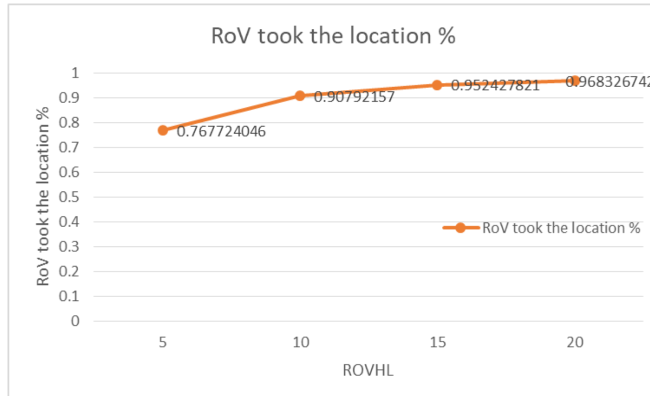

Figure 11: *Ratio of vehicles that have the location affection in RoV that took the location*

Figure 11 shows the increase in Ratio of Vehicles (RoV) that have taken the location data, and this ratio describes the ratio between the car that has started in our system without location data or lost it in the way and the car that has used our system to have the location data, the results have shown that the more nodes start with location, the more useful our system is. This useful scenario is limited to almost 15% of the cars having the location data and after that any more increase with the value will not affect our system with more that 1% to 2% at max, so from this figure we can consider 15% as the ideal value for this factor.

6 Conclusions and Recommendations

GPS is not available in all environments or places as sometimes the location provider is offline or the area is not covered by GPS satellites or the accuracy of the location data that the node has is low, and in order to get an accurate location with a path from source to destination using GPS, well known map direction using any map application like Google maps needs to know your most accurate current location. Our system is a new system that relay on VANET network to make connection between vehicles in the road to transfer the relatively physical locations between nodes, here in this thesis we have studied the ability of such systems, and we have studied the impact of changing the most powerful factors that the system has. The five factors that we have studied are road length, number of cars, car speed over side's lanes, the connection radius for the cars and other nodes among the networks and the Ratio of Vehicles that already have the location data, and finally the results that we have accomplished in our study confirm that a system such as ours can add values to the accuracy with more than 3% from the average of the accuracy that the system have already started with, and we can transfer the location data to more than 95%

of total VANET nodes. The work that has been done in this thesis is considered as a single step in the science long journey and many modifications and future works are available to use in Tracking system or we can use it in safety application to give us many solution or ways to do it, that we can consider very important for the benefit that it introduced to all mankind in daily basis.

References

[1] Schiller, J., & Voisard, A. (Eds.). (2004). Location-based services. Elsevier.

[2] Kupper, A. (2005). Location-based services: fundamentals and operation. John Wiley and Sons Wadsworth, pp. 123-135, 1993. (Book style).

[3] Dorf,David (2012). Retrieved from https://blogs.oracle.com/retail/entry/5_ways_to_determine_mobile.

[4] Fascista, A., Ciccarese, G., Coluccia, A., and Ricci, G. (2017). A Localization Algorithm Based on V2I Communications and AOA Estimation. IEEE Signal Processing Letters, 24(1), 126-130.

[5] Reza, A. T., Kumar, T. A., and Sivakumar, T. (2016, March). Position Prediction based Multicast Routing (PPMR) using Kalman Filter over VANET. In Engineering and Technology (ICETECH), 2016 IEEE International Conference on (pp. 198-206). IEEE.

[6] Patra, S., Calafate, C. T., Cano, J. C., Veelaert, P., and Philips, W. (2016, October). Determining the relative position of vehicles considering bidirectional traffic scenarios in VANETS.In Proceedings of the 2nd Workshop on Experiences in the Design and Implementation of Smart Objects (pp. 6-10). ACM.

[7] Zarza, H., Yousefi, S., and Benslimane, A. (2016). RIALS: RSU/INS-aided localization system for GPS-challenged road segments. Wireless Communications and Mobile Computing, 16(10), 1290-1305.

[8] Rohani, M., Gingras, D., and Gruyer, D. (2016). A novel approach for improved vehicular positioning using cooperative map matching and dynamic base station DGPS concept. IEEE Transactions on Intelligent Transportation Systems, 17(1), 230-239.

[9] Pu, L., Liu, Z., Meng, Z., Yang, X., Zhu, K., and Zhang, L. (2015, October). Implementing on-board diagnostic and GPS on VANET to safe the vehicle. In-Connected Vehicles and Expo (ICCVE), 2015 International Conference on (pp. 13-18). IEEE.

[10] Kumar, N. Rodrigues Joel, Lloret, J. and Dua, A.(2015), Replication-Aware Data Dissemination for Vehicular Ad Hoc Networks using Location Determination, Mobile Networks and Applications, vol. 20, no. 2, pp. 251-267, 2015.

[11] Tsai, M. F., Wang, P. C., Shieh, C. K., Hwang, W. S., Chilamkurti, N., Rho, S., and Lee, Y. S. (2015). Improving positioning accuracy for VANET in real city environments. The Journal of Supercomputing, 71(6), 1975-1995.

[12] Chang, B. J., Liang, Y. H., and Huang, Y. D. (2015). Adaptive message forwarding for avoiding broadcast storm and guaranteeing delay in active safe driving VANET. Wireless Networks, 21(3), 739-756.

[13] Rawashdeh, Z. Y., and Mahmud, S. M. (2012). A novel algorithm to form stable clusters in vehicular ad hoc networks on highways. EURASIP Journal on Wireless Communications and Networking, 2012(1), 15.