Appropriate Roadside Units Placement in VANET Networks to Reduce Data Transfer Time

Zinat Salehikiaa, MohammadReza Salehnamadi
Department of Computer, South Tehran Branch, Islamic Azad University,Tehran, iran
Email: Mrezanamadi@yahoo.com

Abstract*:*

VANETs, as a subset of the MANETs, have progressed remarkably in recent years. These networks have an important role in improving traffic, road safety and driver service. In vehicle Networks, vehicle can Communication by vehicle-to-vehicle communication. Since there are fewer vehicles in the environment, there is no vehicle-to-vehicle connection in some areas. Therefore, they use Road Side Units (RSUs) alongside vehicles to send and receive information. Roadside equipment, in addition to information dissemination, has a significant impact on communication, routing and transmission with minimal delay. The efficiency of a VANETs dramatically depends on the density, position and coverage of these units. Because of the high cost of installing and maintaining roadside units, there is no way to cover the entire environment, so we need to install them in places that will save costs and reduce the time needed to transfer information, in addition to reducing costs. The purpose of this paper is to target the minimum number of roadside units in the urban area, so that messages can be transmitted to the roadside units within the range of delayed emissions. In this research, a delay analysis is presented in urban environments, and based on this analysis, the RSU Optimization Placement problem is solved with greedy algorithm and imperialist competitive algorithm. Simulation results show that this roadside installation pattern has improved network performance and reduced cost.

Keywords: Roadside units, Transmission Delay, Urban Area..

1. Introduction

Between vehicles' case networks have different functions in protection of roads' safety and entertainment services for vehicles. One of the most important functions of these networks is to collect data about road status through vehicles and broadcasting the collected data to all vehicles in order to help to avoid traffic jams, to reduce car crashes, and to save fuel consumption [2-3]. Between vehicles' case networks entails on-board units (OBUs) and roadside units [4]. Such networks rely on two types of wireless communications for internal communications: the connection between two vehicles and the connection between the vehicles and the infrastructures. In between vehicles' networks, the collection/broadcasting of the data is carried out through roadside units to the vehicles [5]. In this study we are going to propose roadside placement of partial delayed broadcast (RPPDB) used in between vehicles' network. Since the installation and maintenance costs of roadside units are very high, we can not cover the total area using a great deal of roadside units. Thus, the goal of the present research is to utilize the least roadside units in urban areas in a way that we can transfer the messages to roadside units within the delay boundary to broadcast the intended message. The major procedure entails: 1) the maximum message transfer distance is calculated based on a delay analysis model, 2) it formularizes the item as a covering problem because RPPDB presupposes to cover the roads using roadside units in a way that emergency messages could be transferred into roadside units within the intended delay boundary. Therefore, a set of roads is created for any roadside unit candidate for the coverage, 3) the colonial competition algorithm will be merged with greedy algorithm to resolve RPPDB. First the primary resolutions for the problem are proposed using the greedy algorithm. The optimal resolution has been produced using colonial competition algorithm and utilizing the primary resolution as the primary population.

2. Experimental method

Aslam B and et al. [6] proposed two optimization methods for optimal placements of roadside units aiming at minimizing the report time of vehicles to roadside units in an urban area: Binary Integer Programming (BIP) and Balloon Expansion Heuristic (BEH). BIP method uses distribution and bounding to find an optimal resolution. Meanwhile, BEH utilizes balloon expansion heuristic to find the optimal resolution. In both methods we can observe an optimal or close to optimal performance. Aslam B and Zou C [5] have proposed an optimization pattern for the location of roadside units in highways to minimize the average report time of an accident by a vehicle to the closest RSU. This pattern has been achieved as balloon optimization method through a dynamic process similar to the natural expansion of several balloons within a two dimensional space through which roadside units are considered as balloons and the boundary of each balloon represents the area covered by each roadside unit. Christian Lochert and et al. [7] proposed a resolution which could help a between vehicles' case network to alleviate problems such as limited bandwidth and location change reduction. First, a range congregational pattern is proposed to reduce bandwidth request and then a genetic algorithm is considered to identify the appropriate location for roadside equipments. Therefore, regarding the functions aimed for applied uses and to save time, the identification of the location to put roadside equipment's is optimized. Yingsi Liang and et al. [8], have proposed an optimal framework to regulate and implement roadside units in between vehicles' networks through which the location of roadside units and the selection of framing such as consumption capability level, the type of antenna, or the wireless or wired connection of the network have been formularized as a linear program. The goal is to minimize overall expansion, fixing, and maintenance costs of roadside units. Liu C and et al. [9], proposed a greedy pattern to optimally location of roadside equipment's aiming at the reduction of the number of equipment's in an urban area. In this way the emergency messages could be transferred to roadside units within the intended delayed broadcast boundary. The simulation results showed that this project has been efficient and its time complexity has been less than the current algorithms.

3. Results and Discussion

Considering an urban area with some intersections and roads we can imagine a graph without any directionality. Suppose that G = (V, E) refers to road typology where V refers to the total points candidate to locate roadside units and E refers to roads that connects the intersections together. In primary status, all vehicles have an equal position distribution in the area. V includes all intersections and certain points between each pair of the intersections. Considering t_e, where e ϵ E, the broadcast time is defined as the time through which the messages reaches the end of the road from the start of it. Consider α as endurable delay boundary. For e ϵ E, if > αt_e the road is blocked and the block points are shown as the intersections. Since in [1], it was proved through many tests that intersections are much better locations regarding the potential to broadcast data from locations with road parts to install roadside units, in this research all intersections were selected as candidates for RSU. On the whole, RPPDB deals with covering. Of course, it should be noted that roadside units are utilized to cover roads in a way that emergent messages should be transferred within the boundary of α to the roadside units in roads where accidents or some incidents happen. The goal is to implement the least possible RSUs. A road is covered by RSU if any emergent message from any point in the road could be successfully transferred through RSU within the boundary of α. Here, the goal is to cover all roads in G using the least number of RSUs. Therefore, the implementation of RSU can be turned into a classic set coverage issue. Suppose that j ϵ V and S_j is the sum of the covered edges in area α with the top j. Suppose that S = {Sj | j ϵ V}, in this case, S is a collection of edge sets. Clearly it is apparent that U_j ϵ V S_j = E.

The procedure to calculate S_j for any j, where j ϵ V, is as follows:

1- For the intended delay boundary, calculate the transfer distance required to transfer the data.

2- For each pair of the tops (p, q) = e ϵ E, calculate the shortest distance d (p, q), where d(p,q)=d(q,p).

3- Find the set S with two states as shown in the figures below. Figure 1 shows a state through which $d(e) + d(p, j) + d(q, j) \leq 2 * \alpha$. This means that the emergent messages in any point e join j after passing from q or p. figure 2 represents a state through which we have $d(e) + d(q, j) \leq \alpha$. This means that the emergent messages in any point e join j passing through q.

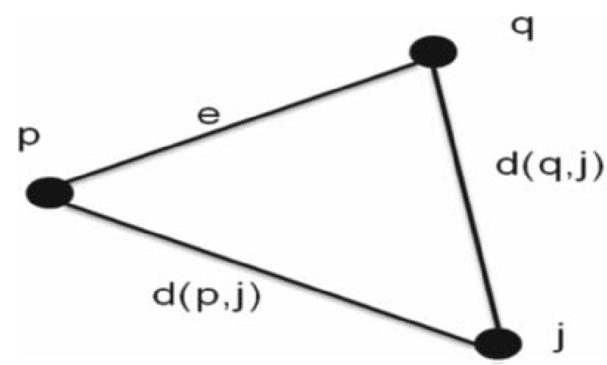

Fig.1. First state of the set

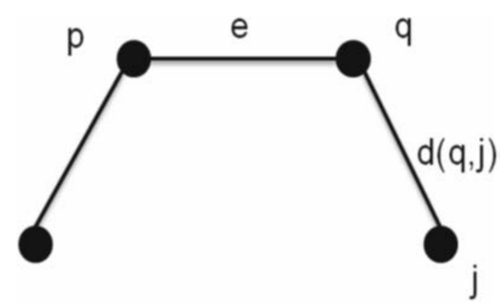

Fig. 2. Second state of the set

Therefore the algorithm to find the set of S as FSS algorithm has been represented as follows:

Algorithm1 FSS Algorithm
1: for $\forall e = (p, q) \in E$ do
2: for $\forall j \in V$ do
3: $Sj= \{e|d(e) + d(p, j) + d(q, j) \leq 2 *\alpha\} \cup \{e|d(e) + d(q, j) \leq \alpha\} \cup \{e|d(e) + d(p, j) \leq \alpha\}$
4: end for
5: end for

Greedy algorithms can resolve NP in multiple sentence forms. Also they can resolve the big index issues. The greedy algorithm is appropriate to resolve this problem because RPPDB deals with finding the optimal resolution from among all possible resolutions regarding the placements and the composition of candidates for RSU. The colonial competition algorithm can resolve RPPDB to achieve the optimal resolution. Meanwhile, as a probable smart algorithm search, it consumes a great deal of time. Therefore, the problem has been resolved using colonial competition algorithm and merging it with a greedy algorithm. In this way and within the first stage of using greedy algorithm, we can get the primary resolutions for the problem. In the second stage, the optimal resolution with colonial competition algorithm has been produced and to do so, the primary resolutions were considered as the primary population. To achieve the primary resolutions we do the followings:
Suppose that Sj refers to adges covered by j ϵ V tops. C refers to a subset of V and $N(C)= \cup_{j\in C} S_j$. N(V) = E and we have the function $F(C) = |N(C)|$.

Therefore the issue of the optimal number of RSU for RPPDB is to calculate min $|C|$: $F(C) = F(V), C \subseteq V$ on 2^v.

The concise strategies refer to limitations that reduce the complexity of problem resolution and the simplified problem refers to the similar optimal resolutions for the overall problem. In this problem, there are certain concise strategies.

1) If we have $\exists j \in V, N(j) = S_j = N(V)$, thus j is an optimal resolution and the optimal resolution is only comprized of an RSU j.

2) If there is $\exists i, j \in V, N(i) \subset N(j)$, i is not a resolution.

Based on the concise strategies above we can build up the heuristic function as follows:

$F(N(C \cup \{j\})) - F(N(C))$

Thus, the greedy strategy would be as follows:
Select j ϵ V with $\max(F(N(C \cup \{j\})) - F(N(C)))$.

Algorithm2 HGA Algorithm

Input:
$G = (V, E), N, C = \emptyset$
Output:
C: minimum subset of V which covers E
1: $EE \leftarrow E, VV \leftarrow V$
2: while EE _= ∅ do
3: if $\exists j \in VV, N(j) \setminus N(C) = N(VV) \setminus N(C)$ then
4: select j
5: else
6: Select $j \in VV$ with $\max(F(N(C \cup \{j\})) - F(N(C)))$
7: end if
8: $C = C \cup \{j\}$, $EE = EE \setminus N(j)$, $VV = VV \setminus \{j\}$
9: end while
10: return C

In the next stage we have used the colonial competition algorithm on locating roadside equipments. A vector with indexes of 0 and 1 with length of S related to all RSU candidates could be observed. If a top is selected to install RSU, the amount of vector index would be 1 and if not, it would be equal to 0.
To guarantee the performance of colonial competition algorithm, a primary resolution has been built as the primary population through a greedy algorithm. The greedy algorithms can estimate the optimal resolutions. Meanwhile, sometimes they can lead to worse resolutions in low probability cases. Based on the evolution of the primary population, the optimal resolution is produced with a closer amount.
In this study, the target function refers to the sum of indexes of each country equal to the number of parameters with amount 1. In other words, the resolution equals with the number of stations selected to implement RSU where the goal is to minimize the amount.
Like other evolutionary algorithms, this algorithm starts with a number of some random primary populations and each of them is known as "a country". Some of the best elements of the population (known as the genius ones in genetic algorithms) are selected as imperialists and the rest are known as the colonies. The colonists can absorb these colonies using a certain approach considering their own authorities (refer to [1] for more study). The overall power of any emperorship depends on both parts comprising, known as the imperialist country and its colonies. The mathematical representation of such dependency is modeled regarding the definition of emperor power as the sum of the power of the imperialist country in addition to the percentage of average power of the colonies. As the primary emperorships form, the imperialist competition starts among them. Any emperorship which is not successful in colonial competitions and can not enhance its power will be removed from the scene by the rivals and thus the imperialist competitions gradually add the power of the bigger emperorships and the weaker emperors will be removed. The emperors would be forced to develop their colonies to increase their own

power. Consequently, the pass of time leads the colonies to get closer to the power of the emperorships and we can observe a type of convergence. The integration of colonies with the emperorship will be achieved when the colonies are so close to the emperor.

In this research RSU was implemented in two parts. The first part dealt with the change of city scenario into a graph typology of the road G to find coverage sets of Sj roads regarding j ϵ V. The second part deals with RSUs placement. To assess the RSU implementation approach mentioned above, a model of random urban scenario has been utilized. This model covers an area of 10 km * 10 km. There were 50 intersections and 92 roads in this model. To simplify it, we call the integration of greedy algorithm and colonial algorithm as ICAHGA. The simulation has been done regarding both two traffic jams and average traffic states. The simulation program utilized was MATLAB programming language. The results were compared with colonial competition algorithm and greedy algorithm.

Figures 3 and 4 represent a comparison of colonial competition algorithm, greedy algorithm, and ICAHGA regarding broadcast delay boundary of α={30s,40s,50s,60s,70s,80s,90s,100s,110s,120} when we observe TFD r=0.01 vel/m and TFD r=0.015 vel/m, respectively.

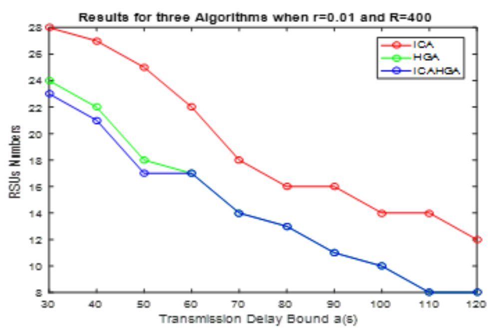

Fig. 3. The number of RSUs for the time when r=0.01, and R=400m

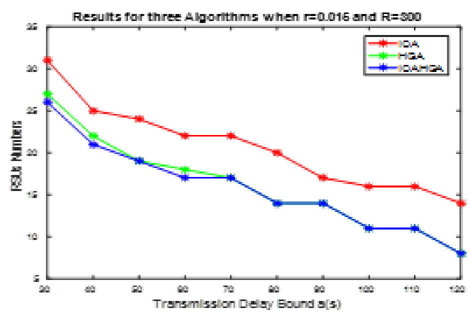

Fig. 4. The number of RSUs for the time when r=0.015, and R=300m

As it can be observed, increasing the amount of α leads to a reduction in RSUs. On the whole, ICAHGA algorithm has had a better performance compared to the colonial competition algorithm and greedy algorithm. Figures 5 and 6 represents the trends when RSUs reside in a transfer boundary regarding different time delay boundaries as r=0.01, and r=0.015, respectively. The number of RSUs is reduced as the transfer boundary increases. The comparison of these results showed that the number of RSU reduces as TFD r reduce.

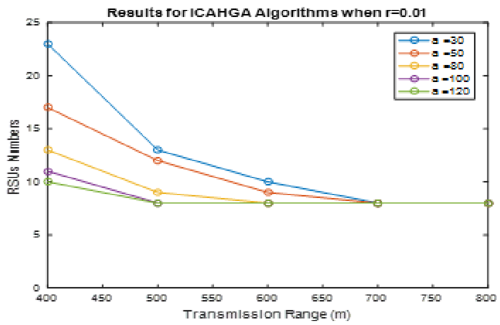

Fig. 5. The number of RSUs when, r=0.01

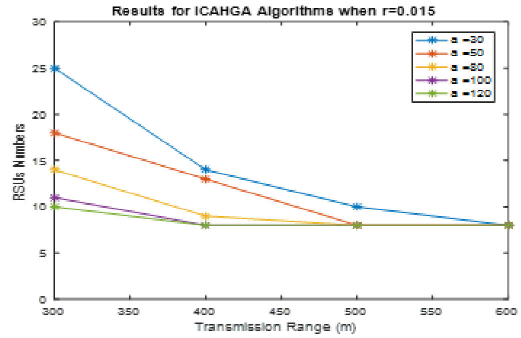

Fig. 6.The number of RSUs when, r=0.015

Conclusion

In this research we have proposed a plan to replace roadside equipments in urban areas using the least possible number of roadside equipments. It can be utilized in roads with incidents mentioned. The emergent messages are transferred to the intended broadcast delay boundaries. The results were compared with results gained from colonial competition algorithms and greedy algorithms. Results of simulations showed that the strategy proposed in this study requires less to cover areas regarding roadside units compared to the other two algorithms.

References

[1] Trullols, Oscar, et al. "Planning roadside infrastructure for information dissemination in intelligent transportation systems." Computer Communications 33.4 (2010): 432-442

[2] Yan T., Zhang W., Wang G., Zhang Y., Access points planning in urban area for data dissemination to drivers, Vehicular Technology, IEEE Transactions on., vol. 63, no. 1., pp. 390-402(2014).

[3] Fang, Yuguang Michael. "Vehicular Ad Hoc networks: Communications on the road [Message from the Editor-in-Chief]." IEEE Wireless Communications 16.6 (2009): 2-3.

[4] Peng, Yanlin, Zakhia Abichar, and J. Morris Chang. "Roadside-aided routing (RAR) in vehicular networks." 2006 IEEE international conference on communications. Vol. 8. IEEE, 2006.

[5] Aslam, Baber, and Cliff C. Zou. "Optimal roadside units placement along highways." 2011 IEEE Consumer Communications and Networking Conference (CCNC). IEEE, 2011

[6] Aslam, Baber, Faisal Amjad, and Cliff C. Zou. "Optimal roadside units placement in urban areas for vehicular networks." 2012 IEEE Symposium on Computers and Communications (ISCC). IEEE, 2012.

[7] Lochert, Christian, et al. "Data aggregation and roadside unit placement for a vanet traffic information system." Proceedings of the fifth ACM international workshop on VehiculAr Inter-NETworking. ACM, 2008.

[8] Liang, Yingsi, Hui Liu, and Dinesh Rajan. "Optimal placement and configuration of roadside units in vehicular networks." 2012 IEEE 75th Vehicular Technology Conference (VTC Spring). IEEE, 2012.

[9] Liu, Chunyan, et al. "Optimal RSUs deployment in vehicular networks." International Conference on Web-Age Information Management. Springer, Cham, 2014.