A Genetic Algorithm for Hybrid VANETs With Synchronous Communication

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ABSTRACT

In this work, we propose a genetic algorithm for solving the allocation of Roadside Units (RSUs) in a Hybrid Vehicular Network with Synchronous Communication. We run our algorithm for several V2V communication ranges and compare the influence of these ranges in the number of chosen RSUs.

CCS CONCEPTS

•Computing methodologies → Heuristic function construction; •Mathematics of computing → *Evolutionary algorithms;*

KEYWORDS

VANETs, Hybrid Communication, Genetic Algorithm

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1 INTRODUCTION

Vehicular Networks [2] (VANETs) are a particular type of mobile network, which is specially designed to the domain of vehicles and pedestrians. In the last years, these networks have received considerable attention from the research community, as well as the automotive industry.

In a Vehicular Network, the communication may happen in three major ways: (i) Vehicle-to-Vehicle (V2V) [1], a pure wireless ad hoc network that in which communication is performed from vehicle to vehicle; (ii) Vehicle-to-Infrastructure (V2I) or Infrastructure-to-Vehicle (I2V) [5], an architecture with wired backbone and wireless last hops, in which the communication occurs through connections between vehicles and communication units, called Roadside Units (RSUs); and, (iii) Hybrid, communication that exploits the V2I and the V2V communications.

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In this work, we propose a new genetic algorithm, called Delta-GA2, for solving the allocation of RSUs to guarantee a Delta Network [5]. The Delta Network is a metric designed to reflect the connectivity experienced by vehicles. Delta is based on two measurements: (i) connectivity duration (ρ_1); and, (ii) percentage of vehicles presenting such connectivity duration (ρ_2).

Different from Delta-GA algorithm proposed by Sarubbi et al. [4], this new algorithm allows the communication between vehicles within a V2V communication range (λ). Our algorithm also allows the multi-hop communication. We test our algorithm for different λ values to measure the impact to use a hybrid network instead of using a simple V2I network.

2 PROBLEM DEFINITION

A Deployment is $\Delta_{\rho_2}^{\rho_1}$ whenever ρ_2 percent of all vehicles must be connected to roadside units during ρ_1 percent of the trip. Formally:

Definition 2.1 (Deployment $\Delta_{\rho_2}^{\rho_1}$). Let R represent a road network, and $V = \{v_1, v_2, \ldots, v_n\}$ represent the set of vehicles traveling on R. Let $C \subset V$ be the set of vehicles experiencing connection during, at least, ρ_1 percent of the trip duration. A deployment is considered $\Delta_{\rho_2}^{\rho_1}$ whenever $\frac{|C|}{|V|} \geq \rho_2$.

3 GENETIC ALGORITHM

In this section, we present our genetic algorithm[3], called Delta-GA2, to solve the Deployment $\Delta_{\rho_2}^{\rho_1}$ with hybrid network and synchronous communication. Our algorithm is based on the Delta-GA algorithm proposed by Sarubbi et al. [4]. Our algorithm has a standard structure with the Evaluation, Crossover and Mutation steps. We also implement the Elitism.

3.1 Encoding

In this work, we represent an individual as a list of coordinates (x,y) to install RSUs. The size of this list defines the number of RSUs present in the solution. Figure 1 represents an example of one individual with 8 RSUs.

RSU 1_B		RSU 2_B		RSU 3_B		RSU 4_B		RSU 5_B		RSU 6_B		RSU 7_B		RSU 8_B	
47	43	41	39	40	41	33	42	38	45	41	49	36	44	37	40

Figure 1: Representation of an individual with 8 RSUs

3.2 Decoding

The individual decodification process allows computing both V2V and I2V communication. The Algorithms *Decoding Procedure* and *Verify V2V Communication Procedure* show our decoding strategy. Being possible the communication between a vehicle and an RSU in a particular time, the *Add I2V Communication Time* procedure is responsible for adding this communication time in the vehicle travel. The *Verify V2V Communication* procedure verifies, for a given vehicle in a specific time unit all V2V communication possibility using a recursive strategy. Similarity from RSU communication, the *Add V2V Communication Time* procedure is responsible for adding the V2V communication time in the vehicle travel.

Algorithm 1: Decoding Procedure

Data: $M, V, T, U, , Individual$
foreach $\beta \in T$ **do**
  foreach $RSU \in Individual$ **do**
    foreach $k \in V$ **do**
      Add_I2V_Communication_Time(k, RSU, β);
      Verify_V2V_Communication($M, V, T, k, \beta, \lambda, V$);
    end
  end
end

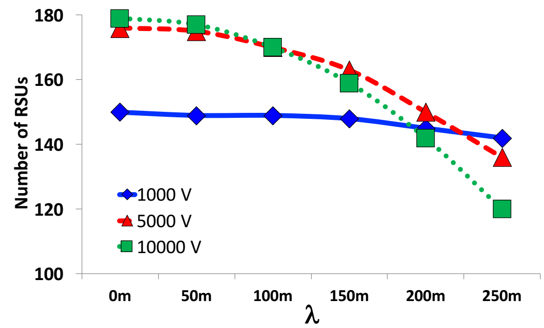
4 EXPERIMENTS

In this Section, we present experiments comparing our algorithm for several different λ values (V2V communication range). Experiments are based on the realistic mobility trace (http://kolntrace.project.citi-lab.fr/) of Cologne, Germany. The Partition Program reads the original mobility trace and partition it into a grid of 100×100 urban cells.

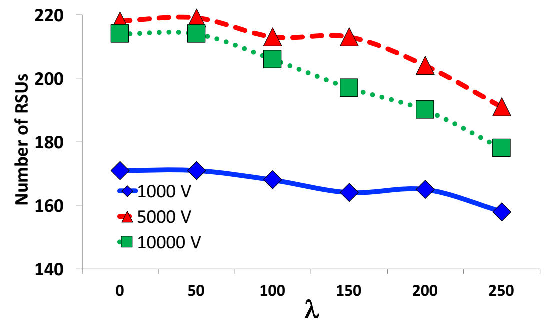
In this work, we present the results for two different pairs of ρ_1 and ρ_2: (i) $\Delta^{0.1}_{0.9}$; and, (ii) $\Delta^{0.9}_{0.1}$. For all instances we run the algorithm 11 times with the following parameters: $\varrho = 200$, $tMut = 0.4$, $tCros = 0.8$ and $\tau = 500$. We run our algorithm for six different λ values ($0m$, $50m$, $100m$, $150m$, $200m$ and, $250m$). When $\lambda = 0$, the Delta-GA2 algorithm do not use the V2V communication.

We present and compare the number of RSUs found in each tested algorithm for different λ values. Figures 2a and 2b present the number of RSUs for each tested scenario: In all the Figures we present the medium instance solution for 1000 and 10000 vehicles instance. For each figure, the x-axis indicates the number of RSUs and, the y-axis indicates the different λ values.

Figure 2 shows that, for the 1000V trace, the number of vehicles does not decreases significantly when the λ value increases. It happens probably because of the vehicles sparsity. As the number of vehicles is small, the number of contact opportunities seems to be rare since the communication via V2V two vehicles must be close enough from each other at the same instant of time. It is also intersting to note that for $\Delta^{0.1}_{0.9}$ when $\lambda = 250$ and $|V| = 1000$, the number of RSUs is smaller than when $|V| = 10000$. On the other side, for 10000 vehicles instance, we can note a more significant gain. For instance, when ρ_1 and ρ_2 are equal to 0.5, the number of RSUs decreases in 32% when we compare the number of RSUs achieved by our algorithm when $\lambda = 0$ and when $\lambda = 250$.



(a) Number of the RSUs $\Delta^{0.1}_{0.9}$



(b) Number of the RSUs $\Delta^{0.9}_{0.1}$

Figure 2: This graphic represents the number of RSUs computed by our algorithm for different λ values. The blue solid curves, the red dashed curves and the green dotted curves represent, respectively, the number of RSUs for 2 different vehicles traces.

5 FINAL REMARKS

We noted that as bigger the V2V communication range (λ), fewer the number of RSUs required to achieve the specific Deployment $\Delta^{\rho_1}_{\rho_2}$. Furthermore, we observed that the number of vehicles traveling the road network impacts the algorithm final results. When we have few vehicles, the contact opportunities are rarer, and it is necessary more RSUs to achieve the QoS specified by Deployment $\Delta^{\rho_1}_{\rho_2}$.

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