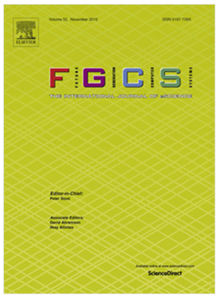

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An evolutionary algorithm for roadside unit deployment with betweenness centrality preprocessing

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Abstract

This paper presents a genetic algorithm strategy to improve the deployment of roadside units in VANETs. We model the problem as a Maximum Coverage with Time Threshold Problem and the network as a graph, and perform a preprocessing based on the betweenness centrality measure. Moreover, we show that by using a simple genetic algorithm with few interactions, we achieve better results when compared with other strategies. We consider five realistic datasets to evaluate our approach and the experiments show that it finds better results in all scenarios, mainly when compared with the greedy-based approach, which increased up to 20% of the vehicle coverage in specific scenarios. Additionally, the betweenness centrality preprocessing helps the solution convergence by selecting candidate intersections, which suggests that this preprocessing is a good measure to explore in these scenarios.

Keywords: Vehicular networks, Roadside unit deployment, betweenness centrality.

1. Introduction

The Vehicular Ad Hoc Network (VANET) is a type of Mobile Ad Hoc Network that provides Intelligent Transportation Systems (ITS) through vehicular safety applications, optimized vehicular traffic routing, and real-time applications, such as mobile infotainment [1]. In a VANET, vehicles are mobile nodes[1] that send messages to other vehicles and to Road Side Units (RSUs), which are fixed infrastructures along the roads that provide vehicle connectivity in sparse areas. The communication among vehicles is called V2V (Vehicle-to-Vehicle), while among vehicles and infrastructures is called V2I (Vehicle-to-Infrastructure).

The RSUs play a key role for data dissemination along the roads, since the dynamic traffic patterns in V2V change network topologies and imply fleeting connectivity and continuous V2V disconnections. On the other hand, V2I allows vehicle communications in sparse or low density areas, in spite of the costs of RSUs and network overhead imposed. Therefore, an important problem arises: *given a set of k RSUs, we need to optimally deploy each RSU to achieve a maximum connection coverage threshold time among vehicles and RSUs.*

In spite of many efficient well-known solutions developed for other ad hoc networks [2, 3], VANET's unique features require different approaches to cope with the dynamic behavior of VANET environments. For instance, Trullols et al. [4] propose different solutions to deploy RSUs with different approaches, such as greedy and the divide to conquer strategies, where the first one achieved better results.

In this work, we propose a solution for RSU deployment that is based on an evolutionary approach, as well as with a preprocessing that is based on the betweenness centrality [5] and the community detection method [6]. The preprocessing reduces the search space and consequently improves the convergence time. This improvement is very important, since we can apply this solution to activate RSUs in real time, i.e., given a set of pre-installed RSUs, the system can activate a subset of them on the fly. Other scenario is when we need to determine virtual RSUs or anchor zone [7], i.e., we automatically identify a specific area to disseminate an information in a V2V communication.

Our proposal improves the vehicles' connectivity coverage threshold time for five specific scenarios, when compared with Trullols greedy approach. We evaluated our approach over different scenarios: *i.* three datasets that focus on low simulated traffic, with 9,876, 11,632 and 13,578 vehicles [8]; These datasets represent the Baar, Baden and Winterthur cities, in Switzerland; *ii.* one dataset that represent low simulated traffic, with 70,537 vehicles [8]. This dataset represents the Zurich city, in Switzerland; and *iii.* one dataset that correspond to a high and realistic urban traffic, with more than 700,000 individual car trips. This dataset represents the Cologne city, in Germany [9].

The experimental results suggest that our approach finds a better RSU deployment in all scenarios, which

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[1] We use the terms vehicles, nodes and cars interchangeably.