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A New Method for Predicting Cluster Stability in VANET Based on the Birth-Death Process

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***Abstract*: One of the main characteristics of a Vehicular Ad-hoc Networks (VANET) is high mobility. Therefore, the high overhead and end-to-end delay are natural results. The prediction of future movements for vehicles provides traffic observations to improve and enhance the network performance and to serve the VANET applications. The clustering approach is a popular technique used in most studies to deal with the network's dynamic topology. In most studies, the clustering algorithms are tested and evaluated according to the cluster head (CH) selection approach. Selecting a suitable CH will lead to the prolonging of the cluster lifetime. A long life time represents an indication for cluster stability, also known as cluster maintenance. Cluster maintenance has got less consideration by the previous VANET studies. The stability prediction represents a challenging task in the clustering approach. This paper highlights the stability prediction in the VANET's Highway scenario. It proposes a new approach to evaluate the vehicle's cluster stability prediction by utilizing the stochastic process. The modeling of joining and leaving takes place using the birth-death process as a stochastic process for evaluating the stability of the clustering algorithm. The main advantage of this approach is to predict and evaluate the vehicle cluster stability with time, using a new mathematical model.**

Keywords: VANET, clustering, birth-death, stochastic process, stability, cluster maintenance, Markov.

I. Introduction

Vehicle Ad-hoc Networks (VANETs) are networks that can supply information on roads to the drivers in order to make driving safe and easier. It will become widespread in the very near future, creating a notable change to human lives [1]. The enormous safety, suitability, and trade possibilities of VANETs are the causes of VANET's spread. VANETs are simply multi-agent wireless networks that are constructed to solve traffic issues by allowing vehicles to communicate together [2]. It provides wireless communication among vehicles by using a dedicated short-range communication (DSRC), which is essentially improved by IEEE 802.11a, and Long Term Evolution (LTE) [3]. Each vehicle contains an on-board unit (OBU) sensor to connect with the nearby vehicles or Road Side Unit (RSU) if it is the CH according to its coverage area and function. There are many models built to implement, support, and improve VANET [4], [5].

However, there are many issues in VANET, such as efficient data dissemination, network scalability, and stable network topology. In order to study VANET's behavior and evaluate its performance, the clustering technique must be the first step to control its changeable topology and to build a meaningful group of vehicles, as shown in Figure 1. The clustering technique contains three phases: cluster creation, cluster head (CH) selection, and cluster maintenance. Most of the related studies have focused on the second phase (CH selection) of any clustering process, while very few studies considered the last phase (cluster maintenance). The stability of vehicle clusters has a high impact on VANET performance [3]. The motivations behind clusters stability prediction are related to the nature of VANET, such as dynamic changes in topology, high speed, and frequent disconnection in networks. In addition, the cluster head (CH) stability plays a crucial role in network scalability and robustness. The stable clusters refer to good performance metrics and QoS. Most of the researchers focused on CH selection methods to improve the stability of the clustering process. The researchers used the performance metrics to evaluate the cluster stability depending on CHs selection process, CHs duration, and CHs lifetime [4]. In this study, the cluster stability is measured and evaluated depending on the stochastic process (Birth-Death process), using the probability of losing or winning one vehicle in each cluster. The process is modeled using a proposed mathematical model to estimate the stability of clusters by means of a set of assumptions derived from probability [5].