Ain Shams University
Faculty of Engineering
Computer and Systems Engineering Department

Prediction-based Clustering Scheme for Vehicular Ad-hoc Networks

A Thesis
Submitted in Partial Fulfillment of the Requirements
For the Degree of Doctor of Philosophy in Electrical Engineering
(Computer and Systems Engineering)

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Statement

This thesis is submitted to Ain Shams University in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Electrical Engineering (Computer and Systems Engineering).

The work included in this thesis was carried out by the author at Computer and Systems Engineering Department, Faculty of Engineering, Ain Shams University.

No part of this thesis has been submitted for a degree or a qualification at any other scientific entity.

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Thesis Summary

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Prediction-based Clustering Scheme for Vehicular Ad-hoc Networks

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Vehicular Ad-hoc Networks (VANETs) are a subclass of Mobile Ad-hoc Networks (MANETs) and the general characteristics of VANETs are typically inherited from MANETs. However, VANETs exhibit several unique characteristics such as the large scale of the network, high mobility, and dynamic network topology. Hence, VANETs unique characteristics might cause frequent disconnections of the communication links resulting in an increased overhead of the communication protocols in terms of extra messages and time delay. Therefore, VANETs face diverse considerable challenges that instigate developing efficient communication protocols.

Creating a hierarchical structure by clustering is widely introduced as an emerging research topic in VANETs to make the network topology less dynamic, maintain a level of coordination between neighboring vehicles, and hence improve the networks overall performance. Typically, clustering is achieved by partitioning the network into smaller groups that are called clusters. A cluster is composed of a cluster head (*CH*) and cluster members (*CMs*); the *CH* is chosen among the *CMs* to manage the cluster and coordinate between the members of the cluster, while the remaining *CMs* locally communicate with their associated *CH*.

From another perspective, predicting the future movements of the vehicles is possible due to the restrictions of the road topology, urban layout, and traffic constraints. Hence, the accurate prediction of the vehicles future movements could play a crucial role for both building efficient vehicular communication protocols and enhancing the vehicular transportation systems.

Thus, this thesis is concerned with two major contributions. The first one is to follow the guidelines of systematic literature reviews in order to provide a premier and unbiased survey of the existing mobility prediction-based protocols for VANETs and develop novel taxonomies of those protocols based on their main prediction applications and objectives. Whereas the second contribution of this work is to develop an efficient clustering scheme for VANETs that benefits from the ability to predict the vehicles future movements.

In this thesis, the mobility prediction in VANETs is briefly reviewed with reference to their prediction aims, techniques, use cases, and challenges. Also, each category is discussed with a focus on the prerequisites, advantages, and limitations. In order to figure out the potential usefulness of the mobility prediction in VANETs, usage and performance analysis of the mobility prediction are provided. Additionally, a derivation is provided for the appropriateness of utilizing each prediction aim/technique for the varied use cases.

On the other side, a novel mobility prediction-based efficient clustering scheme (MPECS) is proposed to provide a more stable cluster architecture for VANETs with minimal clustering cost. An analytical analysis is discussed to explore the parameters set that improve the overall performance of MPECS. Also, performance evaluation via simulation is presented to evaluate MPECS compared to four existing clustering schemes for VANETs. The conducted evaluations show a close agreement between simulation and analytical results and demonstrate that MPECS can significantly improve the stability of the clustering architecture with minimal overhead. Finally, our conclusion and the future work are presented.

<u>Keywords:</u>

Mobility prediction, Applications, Objectives, Clustering, Voronoi diagram, VANETs.

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Contents

List of Figures

List of Tables

List of Abbreviations

ACAR	Anchor-based Connectivity Aware Routing
AODV	Ad-hoc On-demand Distance Vector Routing
AP	Access Point
ASTM	American Society for Testing and Material
AU	Application Unit
AV	Automated Vehicle
BP	Beacon Periodicity
CAV	Connected and Automated Vehicle
CH	Cluster Head
CM	Cluster Member
CSMA/CA	Carrier Sense Multiple Access with Collision Avoidance
CV	Connected Vehicle
DCF	Distributed Coordination Function
DSR	Dynamic Source Routing
DSRC	Dedicated Short-Range Communication
DTNs	Delay Tolerant Networks
ECN	Electronic Chassis Number
ELP	Electronic License Plate
EMA	Exponential Moving Average
ETSI	European Telecommunications Standards Institute
ETX	Expected Transmission Count
FHWA	Federal Highway Administration
FSR	Fisheye State Routing
GMM	Gauss-Markov Mobility
GPRS	General Packet Radio Services
GPS	Global Positioning System
GPSR	Greedy Perimeter Stateless Routing