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Auto-Configuration for VANET, Integrated with Regional Code Association Architecture

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Abstract. The Auto-Address Configurations Protocol (AACP) for Ad-hoc networks necessitates appropriate application. The ACCP for Vehicular Ad-hoc Networks (VANET) stresses even more efforts, as assumption of having nodes (vehicles) to be configured a priori does not support the notion for such networks that mostly remain in structure of mobility. Although AACP for VANETs have been explored prior to this work, but one way or other, the hybrid (infrastructure and Ad-hoc networks) address configuration still remains in hunt. In this research effort we attempt to tackle the problem of auto-configuration for VANETs and design a protocol that supports hybrid environment, that seems be the part and parcel of this type of networks. We propose a protocol termed Regional-Based Auto-Configuration Protocol Association with Coding Architecture (RAPACA) for VANETs. The RAPACA tackles the auto-configuration issues, considering the V2X topology, combines a cluster-based approach CAVNET. The CANVET was proposed in our previous work and designed to support ad-hoc part of VANETs. The combination RAPACA and CANVET is a first approach with regards to hybrid auto-configuration for VANETs and brings immense improvement in term of connectivity, configuration time and scalability of network.

Keywords: Region, Cluseter Head, HMIPv6, MAP.

1. Introduction

Auto-configuration for the moving vehicles covers an important aspect of VANET, a network that is said to be theoretically infinite in nature [2]. In order to have an effective communication in the network with desired vehicles, the vehicles have to be identified uniquely and be provided a unique identifier automatically. The auto-configuration protocol not only has to assign a unique IP address but it also has to assign and configure it within minimum time duration, considering high-speed mobility of VANETs. The auto-configuration protocols [3][4][5][6] for networks like MANET cannot simply be tossed up to VANETs, due to significant difference in mobility behavior and pattern.

A correctly designed IP addressing scheme remains one of the fundamental issues for any communication network, considering VANETs it turns out to be very important issue due to high speed mobility, unpredictable acceleration and deceleration, and unpredictable movement of vehicles along the roads. A well thought addressing scheme, in return offers a better communication with the source and destined vehicle in VANET. In this paper we introduce RAPACA protocol that considers CAVNET protocol enhancement presented in our previous work [1] with respect to V2X approach of auto-configuration protocol. The CAVNET basically offers a cluster-based approach that covers V2V part of network connectivity, where the available of infrastructure network remains unproductive. The combination of RAPACA and CAVNET proves to be constructive approach to address hybrid nature of network that covers V2X approach. The architecture of RAPACA mostly supports infrastructure part of VANET, and the CAVNET covers the ad-hoc part of VANET. The RAPACA algorithm potentially resolves the issue of auto-address configuration among vehicles irrespective of their speed, and communication environment in the network.

The organization of rest of the paper is as followed. The section 2 enlightens the designed architecture of RAPACA, Section 3 is dedicated to IP address distribution mechanism with respect RAPACA, section 4 explores the RAPACA and IP address combination, and Section 5 highlights conclusions and future direction.

2. RAPACA Architecture

Regional-Based routing protocols for Vehicular ad-hoc networks have been the interest of research community recently but Regional-Based IP address distributions somehow remained out of spotlight for VANETs. The designed architecture of RAPACA protocol can be applicable anywhere from macro to micro levels. In this paper a micro level area is focused and the Beijing city of China is kept in the consideration for design at micro level approach. We meet the design of city with **R**egional **C**oding **S**ystem (RCS) inspired by [11] as expressed in Fig.1.

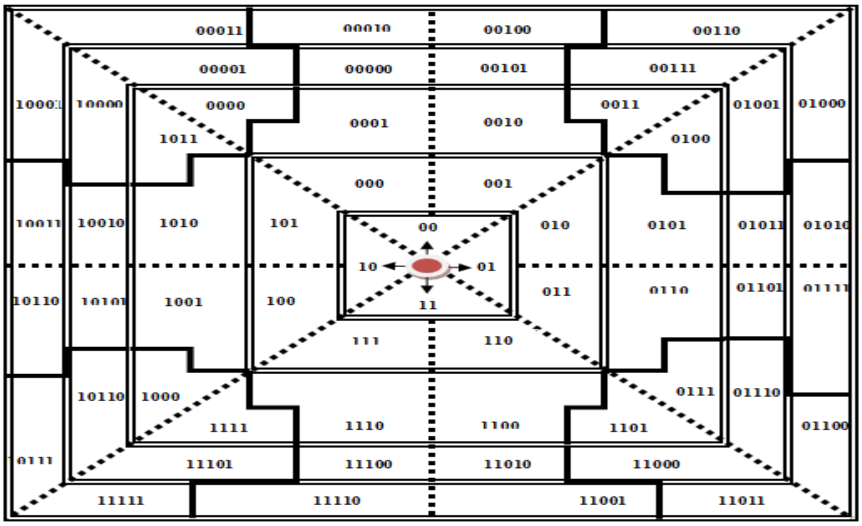


Fig.1 RAPACA Architecture

The respected city is designed with accordance to some ring roads mechanism, where more than 500 bus routes [9] available. The RAPACA supports the implementation of hierarchical Mobile IPv6 protocol at infrastructure network level, where a Mobile Anchor Points install in each direction of RCS, supports the network availability for the nodes moving in the vicinity of Base State (BS) and Road Site Units (RSU) or Access Router (AR). In addition to that a cluster-base approach comes into the act, running under the vicinity of BS, AR, in order to prolong connectivity of mobile nodes. The cluster-based approach not only prolongs the connectivity of ordinary vehicle to network but also it improves network stability and helps to reduce frequent reconfiguration request which has not been considered in ACCP designed for VANETs earlier.

The design of RAPACA as demonstrated in Fig.1, supports four MAPs considering each direction (such as 00 MAP covers the area from South West to North West, 01covers from North West to North East, 11 covers from North East to South East and 10 covers from South East to South West) respectively. These MAPs provide supports to RSU or BS functioning in their respective vicinity. The vehicles moving from one MAP to other will require their Regional Care of Address (RCoA) to be reconfigured. As long as a vehicle remains in the vicinity of MAP it does not need to be reconfigured that in return it saves plenty of overhead as compare to earlier designed auto-configuration protocols [2][7][8] for VANETs.

3. IP Address Distribution

In order to have RAPACA function appropriately, we designed an IPv6 distribution scheme. The careful designed IP address distribution covers RAPACA zones hierarchy completely. The distribution of IPv6 128 bits is divided into four parts as enlightened in Fig.2.

0-63 Network Prefix		64-127 Host ID	
Site Network	CID	Home ID	Host ID
48 bit	16 bit	16 bits	48 bits

Fig. 2 IP Distribution Structure

The designed structure takes first 16 bits from host IP address to present the home network of the vehicle or node. The home subnet is the one, from where the vehicle originally belongs to, and this part of IP address remains with vehicle and never changes as vehicle moves around the different networks. When vehicle moves under the coverage of any cluster it keeps its home subnet ID part intact in it IP address, so before a vehicle makes an IP address request it has home ID part intact with IP address request. This process keeps IP address of joining vehicle unique irrespective of vehicle current placement. If a vehicle has been assigned duplicate IP from the current cluster by a CH even or infrastructure network even then the home ID part remains unique. This guarantees the assigned host ID to vehicle is always unique and in return it reduces the network overhead because of avoidance of DAD.

4. RAPACA and Distributed IP Address Integration

4.1. Clustering Approach

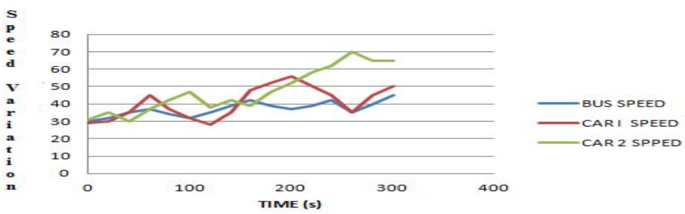
The distributed IP address structure meets the designed architecture of RAPACA. If carefully observed the implementation of distributed structure of IP address with respect to RAPACA coding system, it can be noticed that there are four regions following some binary patterns. The starting binary digits of every regions indicates a pattern to be followed i.e. the close observant will find if starting digits of any region is 01, then rest of the following digits pattern will always be with respect to starting digits. This regional pattern is followed in the home subnet of the IP addressing structure that indicates every MAP to learn two things 1) the region of the vehicle originally vehicle belongs to, 2) the distance of the home subnet of vehicle with respect MAP i.e. as the digits grow in number that indicates the distance of home network from the MAP.

The cluster head selection for the designed protocol aims to follow some simple criteria. For the sake of simplicity we intend to select the buses moving along to road for transportation as cluster heads. To select these buses as cluster head needs to have some basic logic behind. Why buses? When buses are not available then what? Or what about late night timings when system is inactive?

To answer these questions logically or appropriately we defend this selection criteria with logical answers

1) *Buses cover 20% of traffic in beijing city [10]*
2) *Its becomes unproblematic to equip these buses with additional required devices (UTRAN interface) to perform as CHs.*
3) *Its easy to regulate the traffic rules on these buses by the authories.*
4) *These buses mostly follow the average speed criterion, which makes them to be suitable for selection.*
5) *The buses have fix routes to follow, that makes ordinary vehicle to select the suitable bus to join with respect to route and speed.*
6) *The longer vehicle remains connected with the network, the better network performance is achived.*

A simple speed variation with respect to bus and ordinary cars is taken from the real scenario is observed during travelling. Where it was observed while sitting, the variant speed of the bus with respect to two selected cars is demonstrated in Fig.3 that shows an important factor considers the Bus as CH. This demonstration is taken into the account that we can have very improved results as compare to earlier designed protocols for VANETs.



4.2. Cluster-based registration

Once a vehicle is on the road it may either finds itself in the vicinity of home network or it needs to register itself to the current network. The IP registration process is demonstrated in Fig.4. As aforementioned the home subnet of the vehicle remains same in order to avoid DAD process that in return reduces the network overhead. In Fig.4 we take into account the two type of vehicle for the simplicity of implementation, 1) the buses and 2) the ordinary vehicles. The buses when they leave their home network they are bless with IP address spaces to assign the transient IP addresses to the joining vehicles. The ordinary vehicles may get themselves registered to cluster head in order to have Local Care of Address (LCoA). As far as vehicle remains in the regional area of MAP its RCoA will remain same and moves freely. It may join different cluster heads with respect to the speed of the given vehicle. This transparent movement of cluster head and vehicles under the umbrella of MAP reduces amount of reconfiguration problem enormously and reduces reconfiguration effects. The frequent reconfiguration of IP address remained one of the major problems of earlier designed protocols such [2][8]. The designed algorithm of RAPACA allows vehicle to selects either the infrastructure network or a CH smartly. The vehicle selects the CH according to its final destination. The CHs advertise their final destination periodically this allows the vehicle to choose most suitable CH according to their prolonged connectivity. The prolonged connectivity of vehicle with CH brings improvement in the form of network stability that in return reduces overall network loads. How CH manages IP address it is refer in [1].

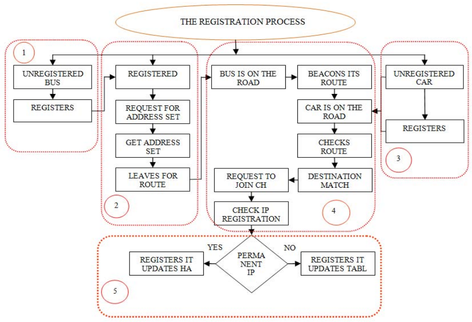


Fig. 3 Registration Process

4.3. RAPACA Algorithm

The RAPACA algorithm in Fig.5 follows the decision making process for ordinary vehicles to join the suitable required network topology, such as either to join the infrastructure network or follow the cluster-based ad hoc network topology. If the requesting node receives the advertisement from both networks, it should join ad hoc network topology preferably according to algorithm. We could prove in processing session the smart selection of main network can provide better and prolong connectivity to ordinary vehicle.

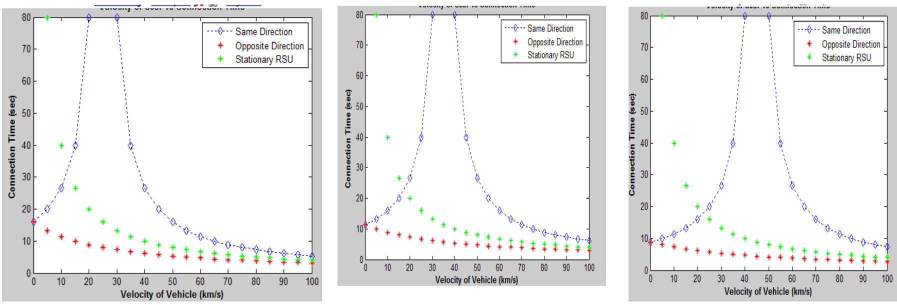
```
Input: cs, ss,
Output: x,
While vehicle is in the vicinity of infrastructure network
    If (ss of CH >= ss* of I.N)
        Then x = 1;
            Chk suitable CH*
            Sending joining request to CH;
            Follow CANVET [1];
        Else
            x = 0;
            Send Joining Request I.N;
            Join the I.N;
    End
End
```

Fig. 4 RAPACA Algorithm

*Suitable Cluster Head with respect to final rout destination, ** cs and ss stand for Constant Speed and Signal Strength

5. Simulation

In the simulation environment we demonstrate 3 BS. The green line show connectivity of ordinary vehicle with stationary BS, the red line demonstrates movement of BS in opposite direction and blue line demonstrates BS moving in the same direction BS. This supports the idea that buses functioning as CH provide better connectivity as compare to earlier designed protocols [7][8], if the selection of CH is done carefully according to routes CH advertise this proves vehicle could have better connectivity for longer time, which was main problem in [2]. In three graphs 6-2, 6-b, 6-3 we keep the speed of CH 25,35,45 respectively and the graphs demonstrate the prolong period of connectivity with CH, that proves if vehicle moving under the vicinity of infrastructure, should preferably join CH in order to have better network coverage.



6-a 6-b 6-c

Fig.5 Connectivity with CH

6. Conclusion and Future work

The designed architecture of RAPACA is a useful contribution to IP address distribution with respected to regional-based distribution. It distributes given city into four evenly divided regions and every region is covered with MAP. The MAP covers number of BS and RSU functioning within the vicinity of MAP. We implemented the cluster-based approach running under the coverage area of BSs and ARs respectively. The lower level cluster-based approach becomes and useful approach in order to avoid occurrence of frequent reconfiguration problem. The frequent request for reconfiguration remained one of the main problems of earlier auto-configuration protocols in VANETs. As cluster-based approach keep connectivity of vehicle for prolonged period, that in return became to reason to have less amount reconfiguration request. In the future we intend to work out the vertical handover process of the designed protocol.

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