A Dynamic Auto-Address Configuration Protocol for VANET Region based Auto-configuration Protocol with Code Association(RAPACA)

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Abstract

The Auto-Address Configurations (AAC) for Ad-hoc necessitates appropriate application. The ACC for Vehicular Ad-hoc Networks (VANET) demands even more effort and the assumption of having nodes to be configured a priori do not support the notion for the networks such as VANET. Although Auto-Address Configuration Schemes (AACS) for VANET have been explored prior to this work, however a hybrid (infrastructure and Ad-hoc networks) address configuration still remains in hunt. In this research effort we try to address the problem of auto-configuration for VANET and design a protocol that supports hybrid nature of VANET, that seems be part and parcel of networks such as VANET. We propose a protocol named Regional-based Auto-Configuration Protocol with Code Association (RAPACA) that addresses the configuration issues with the help of clustering approach, an approach that has been proposed in our previous research work Cluster-Based Addressing Scheme for VANET (CAVNET). The RAPACA improves CAVNET approach as the designed protocol considers hybrid nature of VANET.

Keywords- DHCPv6, Control Server, Cluseter Head, IPv6.

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INTRODUCTION

The increasing growths in wireless networks tempt to involve every device to play its due tasks in order to be the part of connected networks (internet, network of networks). This involvement increasing growth also engages the moving vehicles on the roads and demands them to be the part, to serve and be served as the nodes for sharing information. The impending technology expects these moving nodes (vehicles) to exchange of information with rest of the world. Quite recently these nodes have been blessed with devices known as On-Board-Units (OBUs) to form a network, to establish a Car to Car (C2C) communication for sharing safety information. This C2C communication forms an ad-hoc network. This ad hoc connectivity concept is driven from Mobile Ad Hoc Networks (MANETs) and VANET develop to be known as the subclass of MANETs. The communication among these nodes is developed with a communication protocol called Dedicated Short Range Communication protocol (DSRC). With the help of DSRC Vehicles get themselves in connecting with infrastructure network through the devices known as Road-Side-Units (RSU) installed at road side, to form an infrastructure network and be able to communicate with the rest of the world. But to establish communication with rest of the world, vehicles need to be assigned proper IP addresses. A correctly assigned addressing scheme regarding networks' topologies remains one of the fundamental issues in the field of communication. Auto-Address configuration develops to be very important issue regarding VANET, which addresses the high mobility vehicles along the roads. A proper scheme in return easies proper communication with the source and destined vehicle in the VANET. AACS remains one of the core issues, irrespective of networks types or topologies.

In the arena of IP addressing Dynamic Host Configuration Protocol (DHCP) claims to be very common method for IP address assignment. The advantage of this protocol is it can assign addresses to any of the hosts without any manual efforts from network administrator. The DHCP turns out to be very important protocol for assigning IP address to the fast moving vehicles in vehicular ad-hoc network. The authors in (Das and Fazio, 2007, Tuan, 2010, DSRC) have used this protocol to configure vehicles irrespective their speeds. The auto-address configuration among the moving vehicle invites plethora of disputes to be argued. IP AAC in VANET remains an open issue, because VANET has a potentially infinite extension (Das and Fazio) specially keeping in view the mobility pattern of this network. The vehicles accelerating and decelerating without any well known reasons poses challenges. To overcome the issue of addressing in VANET, this paper applies Regional-Based Auto-Address Configuration (RAPACA) protocol a distributed IP addressing scheme.

RAPACA with the help CAVNET (clustering auto-configuration protocol) presented in our previous work covers the part of network where there is no infrastructure network is available. In the (Bugti and Chunhe, 2011). we discussed clustering approach to tackle the auto-configuration process for vehicle moving in the highways or sparse areas. The combination of RAPACA and CAVNET proves to be handful approach to address hybrid nature of network. The designed architecture of RAPACA supports mostly infrastructure of nature, and with help of CAVNET the ad-hoc nature of VANET is also covered. The RAPACA potentially resolve the issue of auto-address configuration among the moving vehicles irrespective network type. The rest of this paper is organized as fellow. The section II enlightens the state of art in VANET address schemes, Section III discusses the architecture of designed protocol, section IV explores the communication process of the designed protocol, Section V discusses the comparisons of designed protocol with exiting approaches and VI highlights conclusions and future direction.

State Of the Art

Mobile IPv6

The solution to connect vehicle to the Internet with assigned unique IP address, a Mobile IPv6 can be applied and this has been acknowledged in (Soliman et al., 2008). There are number of features which are supported by Mobile IPv6 such as mobility based IP addressing, pack forwarding IP addressing. These solutions on other hand invite problems like handoffs, which result in end to end packet delay and degradation of network performance. To overcome the problems of handoff and degradation, other approach such as Mobile IPv6 with Hierarchical Register Management, Mobile IPv6 address Pre-fetching and Local Retransmission Mechanism . However MIPv6 remains an important candidate to counter the IP configuration problems potentially.

Manet Routing Protocol Application

Although MANET and VANET are different networks, but they share some common commodities, such as the vehicles in VANET are equipped with a transceiver, named On Board Units (OBUs) to transmit and receive information. These OBUs exchange information with Access Points (AP) known as Road Side Units (RSUs) installed by road side. These devices use 802.11p standard communication protocol for VANET, the 802.11p protocol is also known as Dedicated Short Range Communication (DSRC) protocol. The DSRC operates at the spectrum of 5.9 GHz and its apparent communication range is up to 1000 m, for more details on DRSC refer (DSRC). On other hand the standard MANET communication protocol used uses 802.11b referred to as Wi-Fi. The application of Mobile Ad hoc Network (MANET) routing protocol for addressing scheme in VANET has been pertained in [8]. But these distributed addressing algorithms do not comply with dynamic nature of VANET. The direct implementation of these protocols does not meet the fast moving vehicles requirement.

Existing VANET Addressing Protocol

The fast mobility of vehicles, and continuous different direction movements, restricts direct implementation of traditional network addressing protocols to integrate with VANET. The work in (Das and Fazio, 2007) claims to be first VANET addressing protocol named Vehicular Address Configuration (VAC) and exploits the VANET topology. The author enhances DHCP service with dynamically elected leaders to provide a fast and reliable IP address configuration. The VAC organizes some leader's chain connected to each other with help of ordinary vehicles; residing in the communication range of these leaders (at least one leader). The VAC guarantees uniqueness of IP addresses within a defined SCOPE of the leader. It does not guarantee IP uniqueness once the vehicle is out of SCOPE. The problem VAC is If the distance between two leader vehicles exceeds the max_threshold, then one ordinary vehicles within the SCOPE has to be a leader; on other hand if the distance between two reaches to min_threshold, then one of leaders will have to give up the responsibilities of leader. In either of the cases address reconfiguration is required, which is not clearly focused in VAC.

The Centralized Address Configuration (CAC) (Mohandas and Liscano, 2008) applies centralized approach for DHCP server and guarantees to provide unique IP address to vehicles in the urban area. The network area is supposed to be covered with RSU functioning as Access Point (AP) connected centralized DHCP server. The IP addresses are assigned by the centralized DHCP server and requested by AP, functioning as relays agent. As IP addresses are assigned by the centralized DHCP server so the chances of having duplicated IP address in the network remains out of question , but as all IP addressing depend on single centralized DHCP server in dense urban areas, rises questions, 1) it is hard to guarantee the deployment of APs in every corner of urban area, 2) if this assumption is guaranteed, it will be very unrealistic to imagine that AP placed in hotspots (i.e. Shopping mall, public gatherings, movie center or football ground), would be able to meet IP address requests made by accumulating vehicles. 3) If this assumption is also guaranteed, then how about single centralized DHCP server, which has to meet IP address request from every APs in urban area, seems obscure, because DHCP server follows based First Come First Served (FCFS).

The IP addresses assignment in (Tuan, 2010).proposes an efficient way of distributing IP address, uses a hierarchical DHCP servers mechanism, each RSU is connected to a central DHCP server, name Balance Sever (BS). The BS distributes and synchronizes the assignment of IP address pools, which are actually maintained by RSUs. The RSUs do not completely depend on centralized server. The RSUs meet IP address request by themselves, from assigned pool of addresses to them. The application focuses on IPv4 instead of IPv6 which comprises a number of difficulties of implementation and has not been utilized widely up now (Tuan, 2010). A hierarchical relationship among the RSUs and centralized exits, every RSU periodically sends messages to higher level of RSU and receives these periodic messages from lower level RSUs. The problem with HID is it is dedicated for selected area of city, cannot be implemented in the areas where ideal installation of APs is not covered.

Designed Protocol Architecture

Regional-Based routing protocols for Vehicular ad-hoc networks have been focus of interest for the researcher recently (Vandenberghe) but Regional-Based IP address distributions somehow remained out of spotlight for VANET. The designed architecture of RAPACA protocol can be applicable anywhere from macro to micro levels. We consider micro level in this paper and focus on the Beijing city of China. We address this issue with the help of clustering approach and we envision micro level architecture of VANET as shown in Fig 1. Designed architecture functions similar to virtual Mesh Network as described in Fig 2. The respected city is designed with accordance to some ring roads mechanism, where more than 500 bus routes (http://www.bjjgl.gov.cn) available. The designed protocol functions with some hierarchical servers. The root servers termed as Central Control Servers (CCS), covering four different direction of the city i.e. The hierarchy of CCS servers use coding schemes such as 00 CCS covers the area from South West to North West, 01 CCS covers from North West to North East, 11 CCS covers from North East to South East and 10 CCS covers from South East to South West respectively. The CCS cover Access Routers place close to them. Each CCS server processes 14 Distributed Servers (DS) in each direction.

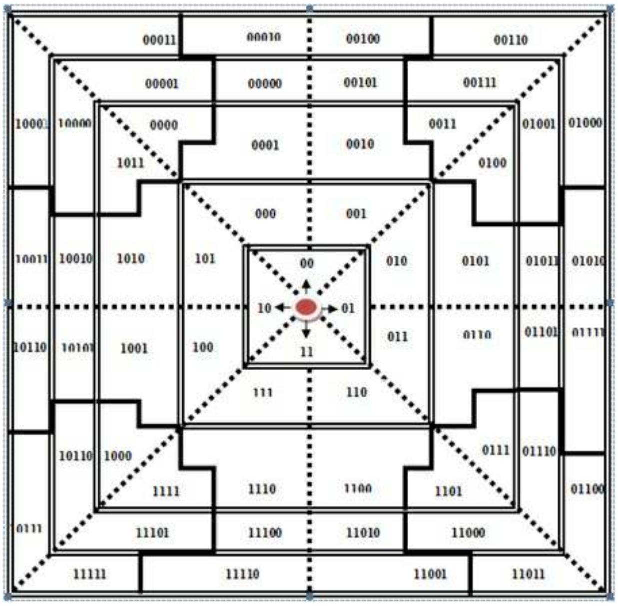
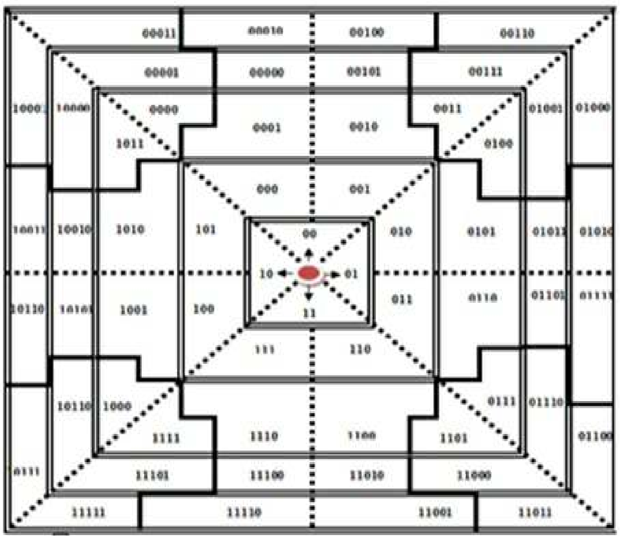


Figure 1: Regional Distribution Architecture

The DSs are connected with core network and provide services to their closely placed Regional Access Router (RAR). The RARs function similar way to RSUs places by the road side as depicted in Fig 3. In addition to that the RARs provide address space to moving Cluster Heads (will be discuss in section V of this paper). The CHs provide IP address to normal joining vehicles. How these CHs manage and maintain IP addressing among each other has been discussed in our previous work termed as CAVNET (Bugti and Chunhe, 2011).



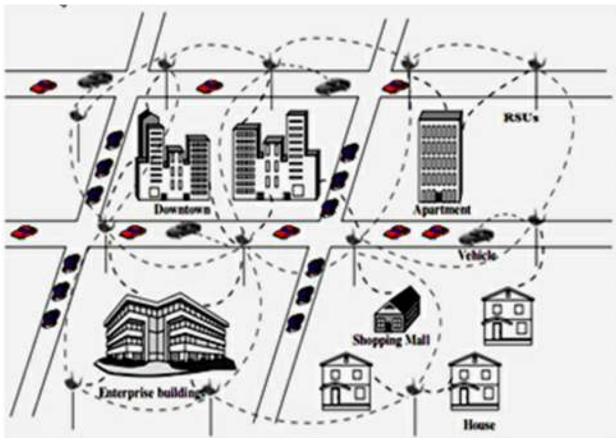


Figure 2: Micro-Regional

The RAPACA covers 64 sectors in this present paper that can be extended with respect to need of the implementation and covering area, or extension of the city.

Regional coding

The Regional Coding (RC) remains fundamental element to understand the division bitwise. The close observation of RC leads us to understand proper coding method applied in Fig 1. Aforementioned there are four CCS servers each covering their respective direction. A vehicle moving in the vicinity of any of the CCSs could easily be detected with respect to its two starting Code bits such as 00, 01, 11 and 10. The rest of the bits followed by these two bits indicate vehicle is still in the coverage area of zone or CCS. The increase in digits indicates increase in distance of the vehicle from the CCSs. The CHs beacon their final destination information through these RCs time to time in order to let normal vehicles select a suitable CH related to their destination. The selection criteria of CH related to normal vehicle destination brings longer during of connectivity with selected CH. We will discuss this method when we discuss CH function in detail in section V.

Hierarchical Server Distribution Mechanism

The designed mechanism of RAPACA is to attain the objectives longer during connectivity of IP addresses with respect to uniqueness. The basic concept is to provide CH an address space directly from RSs through RSU or APs. We would use term APs in place RSUs in this research paper. Aforementioned the CCS are connect with

14 other DSs in their respective covers areas. The DSs are connected with RSs and RSs over all APs in their respective areas. The layer hierarchy of these Servers is demonstrated in Fig 3.

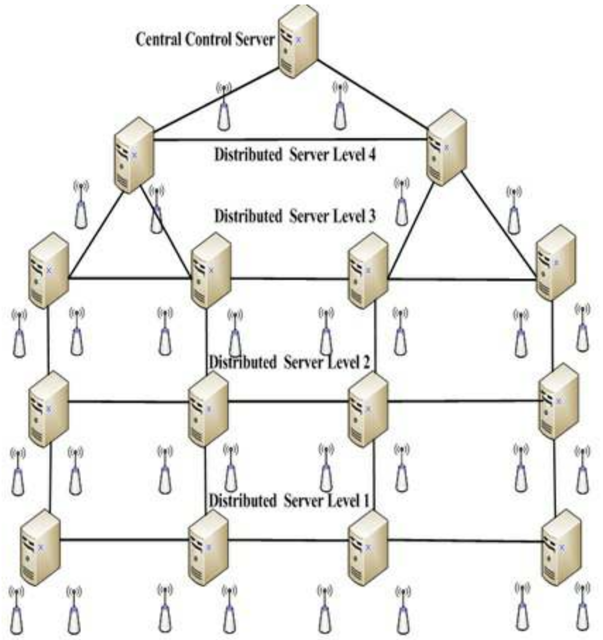


Figure 3: Servers' Hierarchy

The number of APs installed in the regional areas function as address space provide with respect to timing of the day. Provide IP address space to CHs, which in return provides Unique IP address to the vehicles residing in the vicinity of the CH. We don't require complete coverage of regional area with APs as there are possibilities that number of roads in the city may not be covered. As aforementioned there are nearly 500 bus routes in the respective Beijing city. This is where cluster approached has been brought into act. In Fig 4 we envision the place where two APs install at distance may not cover complete transmission and there remains some space in between that is not covered by transmission. This is why vehicles need to join clusters in order to remain connected with transmission. The proper application of cluster approach is discussed in V section. The details of cluster based auto-configuration have been discussed in our previous work (DSRC). The CAVNET was designed in order to keep highway scenario in mind, but RAPACA with help of CAVNET covers hybrid nature of network.

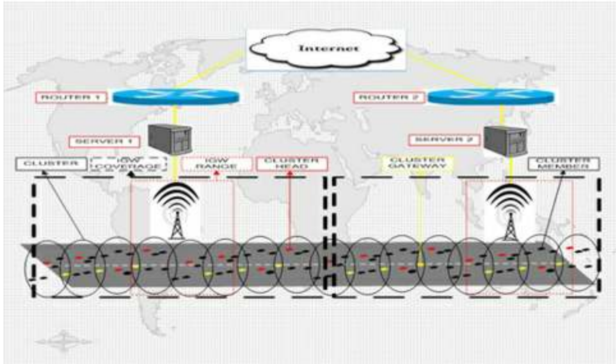


Figure 4: Regional-Based Aps

Dynamic Host Congiruation Protocol (DHCPv6)

The DHCPv6 is a client-server based architecture. The node develops a contact with server for address allocation. The server assigns the address to requesting client from its address pool, based on the allocation mechanism. If client is not in the same link of server it is possible that may use one or more nodes as relay agent to obtain IP address. Here we highlight the possible steps to obtain IP.

1) A solicit message is sent by a client to locate the server.
2) In reply there is response the server, which sends back a advertisement message, this response indicate the possible IP address available to the server.
3) The Client replies by slecting an IP address from a spacific servcer (if there is more advertisement message)
4) The server which is selected replies back accepting the request of selected IP address of the client. This assigned IP address is leased for specific period of time depends up the settings.

Distribution of IPv6

The division IPv6 plays important part in the deployment of the networks. We divide IP address format in main three parts first.

1) The network prefix 64 bits
2) The Ad-hoc prefix 48 bits
3) The Host ID prefix 16 bits.

The 64 bits prefix part is used to cover the part of Internet Gateway the servers connected the globally providing internet services the client's nodes. The 48 bits prefix part is used to cover the ad-hoc connectivity of the network, such as CHs, and rest of 16 bits is used for vehicles jointing the cluster. In the processing section we discuss the cluster head selection criteria that seem to be suit with respect the vehicle movement pattern in discussion for the designed protocol.

B. the ad-hoc prefix 48 bits for cluster heads

The cluster head selection for the designed protocol aims to follow some simple criteria.

1) First we intend to spotlight the buses moving along to road for tansportation. We try to select these buses as our default servers first. To select these buses as default cluster head raises some questions.

a) Why buses?

b) When buses are not available then what?

c) What about late night timings when system is inactive?

To answer these questions should be appropriate and logical in order to understand selection criteria for buses to be selected as CHs. Answer to first question

1) Buses cover 20% of traffic in beijing city.

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) Last but not the least these 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 is connected with the network, the better network performance is achived.

A simple speed variation with respect to buses and ordinary is taken from the real scenario is observed during travelling. Where we took observed sitting in the buses selected two cars with varying speed Fig 5. Demonstrate such variation in speed.

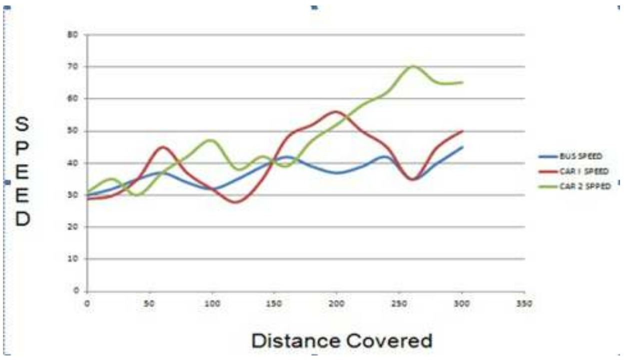


Figure 5: Speed Variation with respect to bus

The answer to second question, in the designed protocol we always keep the candidate CH active, this could be any vehicle that may fellow second selection criterion. In the absence of CH these candidate CH are selected as CHs. The criteria selection for the candidate CH is speed and willingness of the vehicle. The speed criterion for candidate CH is obtained (Kayis and Acarman, 2007).

The answer to last question, we allow AP or RSU to supply IP address to the moving vehicle, when the buses are not available or when these services are not active. One such application have discussed in [CAC], [HID]. In these application AP become responsible to assigned IP address them.

RAPACA application

Let's assume once an ordinary vehicle or buses moves along the road. We assume the in normal condition every vehicle; either bus or ordinary vehicle is registered to some home address before it moves along the road. This assumption is taken for the sake of apprehension that mostly vehicles belong to Beijing city and at the off timings they are parked in their respective region or area where they belong to. Such a straightforward registration process is demonstrated in Figure 6.

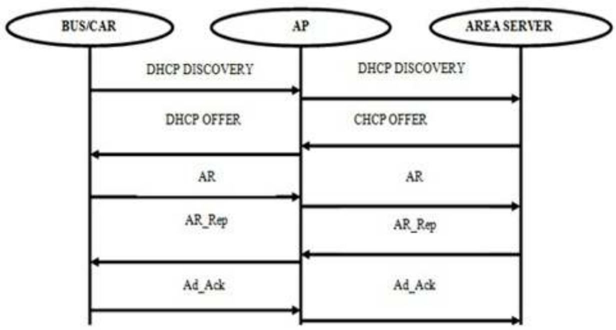


Figure 6: Registration Process

Regristration process of RAPACA

Once the vehicle is on the road leaving their respective registered home network they may require to connect with some established network along the road. As aforementioned along the road we have buses function as CHs. Let's observe process with the flow diagram in Fig 7. How this all process is handled is illustrated in Fig 7. Aforementioned buses or other vehicles are already registered with the home network. The difference between buses and ordinary vehicle remains as buses before leaving there home network are bless with address space to function as CHs. The process of address registration in RAPACA demonstrates that CH beacon their destination address with respect to area coding discussed earlier. This beaconing process contributes a very useful process as vehicles smartly select the CH with same destination, which in return, 1) enhances the connectivity with the CH 2) distributes address configuration requests from single server in rush hours which was main problem in protocol [CAC], 3) vehicles selecting CH with their choice try to remain connected the same CH as long as possible, which should minimize re-configuration problem with very little speed variation, which could be main problem of protocol [VAC].

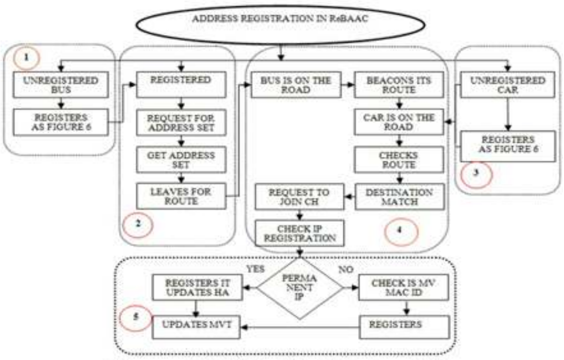


Figure 7: RAPACA Joining CH

RAPACA addressing Scheme

The main focus of this paper remains at the application of IPv6 for VANET. The geo-casting and regional distribution for VANET remains interest of many cooperative companies. The different approaches have been concerned. Such an approach for VANET has been discussed (Vandenberghe). The RAPACA adapts IPv6 extension header that allocates an integration of geographic data in the IPv6 packets. Similar to the approach been discussed in (Vandenberghe), but the RAPACA addressing scheme is demonstrated in figure (Mohandas and Liscanu, 2008) clearly demonstrates different parameters applied for network connectivity.

Mutlicast	Flag	Scope	Init A-C	Cur A-C	Des-A-C	CH-IP	Add-Sp	Ava-IP	T-Stamp	Speed
FF 8 bits	0x1 4 bits	0x5 4 bits	101 16 bits	1001 16 bits	11 16 bits	174::a 16	1-100 16 bit	174::e 174::f 174::g 174::h	unit 16 8 bits	Km/s 8 bits

Figure 8: RAPACA Address Scheme

The first three fields of the addressing scheme are as same as mentioned in (Vandenberghe). The first field is used for regional multicast packets. The second field is used to understand whether the address used format is permanent or transient. Since the addresses used in for network that is built on fly we apply transient approach. The third field used for scope of the network as we target cluster of the network so we set the field to site-local as the approach suits the requirement. The rest three fields are used to indicate initial area-code, current area-code and destination area code respectively. The seventh field indicates the CH ID; the next field is used for address space allocated to this CH. The ninth field is used for available IP address set for ordinary vehicle to join. The tenth field timestamp is used for understand time period of the day as night timings when the buses are not function as CH then the APs function instead of buses. The last field is used to measure the speed parameters of the CH.

RAPACA Multicasting Method

The method multicasting is been used in RAPACA very carefully, when the CHs pass through different RCs. These RCs through RSUs provide information (road condition, road hazard, weather updates and news updates) to CHs in multicast mode the all the member vehicles of CHs are informed through this mode.

RESULTS

As aforementioned a comparative simulation with respect to CAC, HID and RAPACA configuration protocol is simulated using Matlab simulator with following macro-scopic traffic mobility. As defined in table 1.

Table 1 Simulation

Parameter Name	Simulating Values
Simulation Area	10 Km X 10 Km
Number of RSUs Used	3, 5
Arrival Number of Vehicles	50, 50, 50, 50, 50
Velocity of Vehicles	10 - 70
IP address	IPv6
Maximum Coverage Area by RSU	600m
Minimum Coverage Area by RSU	600m
MAC Protocol	IEEE 802.11p
Type of Data Transmission	Constant Bit Rate (CBR)
Mobility Model	Manhattan
Number of Rounds	5

The Table-1 defines the simulation environment of RAPACA protocol. The first consideration is put into practice with respect to the RCS grid layout, discussed in section III. Later the comparison between standard VANET auto-configuration protocols CAC, HID and RAPACA is carried out.

The carried out scenario introduces the measurement with respect to connectivity between the client and server. The connectivity of joining vehicles with their respective servers (i.e. RSUs in CAC, APs in HID and CHs in RAPACA protocol) has been carried out using Matlab.

Initially a RSU is placed on the straight linear road. The ordinary vehicles with different speed metrics pass through the RSU placed by the road side. The connectivity time of passing vehicle is measured against the stationary RSU of CAC and AP of HID. The passing vehicle speed parameter was linearly increased from 10~60 km/h considering the urban traffic flow. The graph in Figure-10 demonstrates the connectivity time of ordinary vehicle to particular RSU or AP. It should be noticed that only one RSU was placed to meet auto-configuration requests as applied in (CAC and HID) protocols.

The graph in Figure-10 demonstrates the connectivity time of vehicle decreases with stationary RSU as speed of vehicle increases. The fast speed of vehicle provides lessens the time connectivity with the server, to configure the vehicle and also lessens time for vehicle to remain in the network. After measuring the connectivity time taken by vehicle with stationary RSU in Figure-10. The graph in Figure-11 includes the RAPACA CHs into same scenario. The CH travels at constant speed (i.e. 25 km/h), and has transmission range up to 600m. The simple demonstration with respect to CH speed is presented Fig 11. Where kept CH speed from 25 to 35 and number vehicle with different speed from 20 to 100 is presented. We observer vehicles with similar speed remained connected to CH for longer time. The speed of CH have been tested against different speed variation as demonstrated in figure 12 and Figure 13.

The compiled results clearly demonstrate significant difference in connection time with CH and stationary servers.

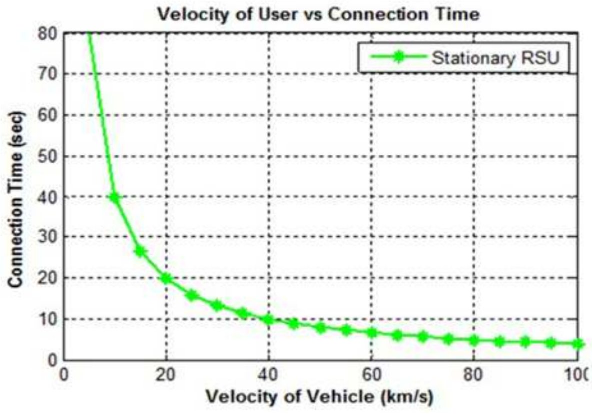


Figure 10

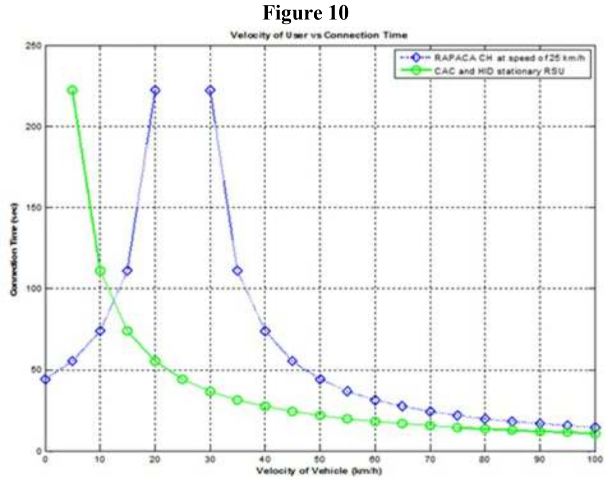


Figure 11

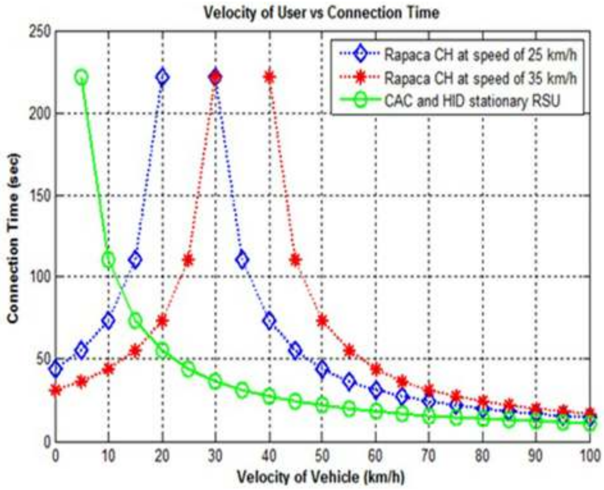


Figure 12

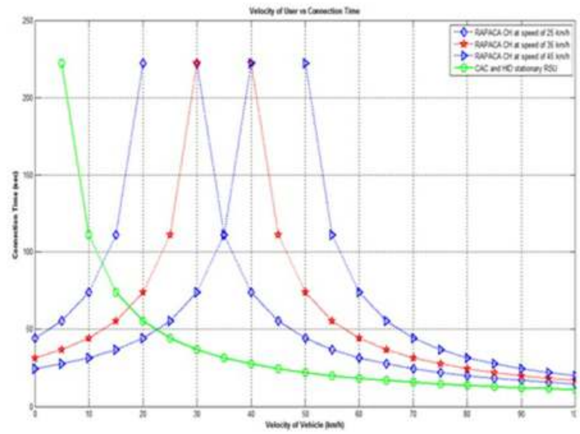


Figure 13

CONCLUSION

In this paper we proposed a protocol named Regional-Based Auto-Configuration Protocol with code association designed for VANET. The designed protocol functions with some area coding scheme. The cluster approach applied in RAPACA demonstrates improved the result of the network connectivity compared to previously applied protocol. This connectivity in return reduce re-configuration problem. The RAPACA is useful protocol with respect to type of networks. As compare to earlier approaches the RAPACA demonstrates as realistic protocol to be implemented in the networks such as Vehicular Ad-hoc Networks.

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