Fructifying the Network Performance of iVANET thru a Rectified Associative Service Mechanism: An Algorithmic Proposal

Mohd Akbar, Shish Ahmad

Abstract- Internet based Vehicular (iVANET) ad-hoc networks are meticulously especial case of normal VANET. It is basically made of a combined wired Internet as well as vehicular ad hoc network for developing a new baby-boom of omnipresent and ubiquitous computing. The Internet connectivity is usually extended to V2I (vehicle to infrastructure) communication whilst ad-hoc networks are used in vehicle to vehicle (V2V) communication. The latency is one of the main matters of concern in VANET. By minimizing distance between data source and the remote vehicle through rectified caching technique along with redefined cache lookup mechanism, the latency can be shortened by a significant factor in iVANET environment. In this paper various cache invalidation schemes are studied and analyzed. Exploring the possibilities of caching schemes which can be hybridized or mutated, paper introduces an algorithmic proposal along with redefined services mechanism for cache lookup and invalidation, which strives for achieving low latency with reduced negative acknowledgement (NACK) in the network. This paper introduces a rectified algorithm for guaranteed delivery of the queried data and efficiently invalidating cache contents at different levels of hierarchy. The proposed work is anticipated to fructify the network performance minimizing the cost and bandwidth utilization during cache invalidation and hence guarantees improved quality of service (QoS).

Keyword: iVANET, mobility, hybrid, mutate, cache lookup, query latency, QoS , iVANET, invalidation.

I. INTRODUCTION

VANET is abbreviated as Vehicular Ad-hoc Network which facilitates vehicle-to-vehicle communication using DSRC channels and Vehicle-to-Roadside Unit(V2I) communication. The entire network is comprised of two major parts, firstly V2V is based on wireless network and secondly the infrastructural network (RSUs) is based on wired network. In particular, Vehicular Ad-hoc Network mimics more like mobile Ad-hoc Networks (MANET).

In the recent past a slightly advanced form of VANET has got attention and recognition in field of Intelligent Transport System (ITS) which is nothing but internet based Vehicular Ad-hoc Network (iVANET).

iVANETs are simply a meticulous case of normal VANET with some additional feature of internet connectivity. The Internet connectivity is usually extended to V2I (vehicle to infrastructure) communication whilst pure ad-hoc networks are used in vehicle to vehicle (V2V) communication.[3]

The communication occurs in two different ways firstly inter-vehicle-communication (V2V) and secondly vehicle to roadside unit (RSU) communication that is vehicle-to-Infrastructure (V2I) [3] communication. V2V communication relies on wireless technology for and the rest of communication process takes on wired technology. For the fact that wired interface bandwidth is usually very high, the RSUs own the wired technology for communication among them.
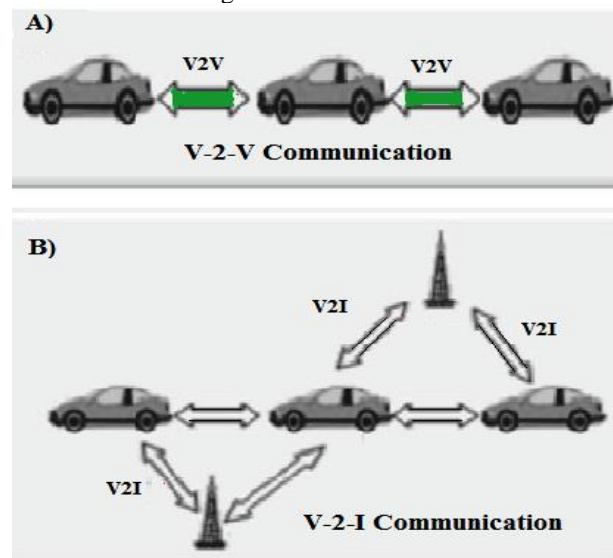

Fig.1. (*V2V & V2ICommunication*)

Each Vehicle uses a device installed on it called as On-Board-Unit (OBU).

OBU is a kind of electronic circuit or device which performs sensing the nearby environment, receiving and transmitting data using DSRC [4] frequency and handling positioning of itself in the network. These OBUs are basically meant for communicating with nearby vehicles as well as to those of nearby RSUs in the network.

Road Side Units are intermediary entities in the networks as they communicate to vehicles and other wired components in the network thru wireless and wired technologies respectively. Road side units (RSUs) are fixed components of VANET and are taken care by privately owned agencies or some government bodies.

The protocols governing the communication of RSUs are dealt, decided and incorporated by its governing bodies either a private or a government one. The chief components lying under RSU are- Remote DATA Server(DS) located on internet, Home Agent(HA), Gateway Foreign Agent(FA) and Access Point(AP).

Fructifying the Network Performance of iVANET thru a Rectified Associative Service Mechanism: An Algorithmic Proposal

AP is the near most RSU which can connect to vehicles for supervising its actions and assisting with the moving vehicles requirements. The Access Point(AP) acts as an intermediary between the vehicle and that of the other RSU components right up-to data server(DS. The vehicle has to contact the access point every time it wishes to connect to the server. At the same time it(RSU) connects to the internet thru subsequent FA and HA in the iVANET in order to provide internet based queried data to requesting vehicle. Each RSU works within a small region and covers a specified but multiple RSUs get connected each other to form even bigger area of network. The size of the vehicular network may initially occupy a small locality and can gradually increase to cover as large area as a whole city[1].

Other elements of networks like Data server, Home agent and Foreign Agent acts as Gateways to the different parts of internet and it is purposely used to facilitate data accessibility which are stored locally at remote home agents (HA) at different locations in iVANET.

Like any other network, VANET has also been remained susceptible to many challenging issues namely, Routing, Security [2] and, Quality of Service issues like Query Latency [12] etc.

Routing has always been a crucial concern in almost every ad-hoc network environment. Since vehicle movements is highly unpredictable in VANET , routing poses even bigger challenges in this environment. The vehicle location keep on changing every now and then so the rout establishment is very fragile and data delivery is susceptible to breakage of V2V link and V2I link. Due to this very phenomena of random and high speed mobility, VANET has prompted researchers to compete with such a routing algorithm which is efficient at dealing these issue and improves the routing performance along with improving network throughput. There are many routing algorithms which support dynamic source routing for randomly moving mobile nodes in ad-hoc networks which lays a foundation for VANET routing [5].

When it comes to improve the quality of service(QoS), reducing the query latency time appears to be the primary concern, and the "Cache Invalidation techniques" are the one which are considered to be the best to do with the latency reduction in the network. Frequent queries within the network lead to the likelihood occurrence of congestion and congestion causes delayed response to queried data request. Therefore it is fair to say that the reduced no. of query, if possible, in the network will contribute to improve network performance by curbing network traffic.

This can be achieved by introducing concept of caching within communicating entities in the network. So the data which are very much likely to be accessed often now and then, can be kept inside cache memory of vehicles and nearby APs. With the Cooperation of cache content sharing a high throughput of network and low latency can be achieved.[10][20][28]

There are many traditional Cache invalidation techniques which can be applied only in MANETs at present. But these techniques are not much compatible and fruitful when are applied to the VANET only because of the fact that the nodes exhibit highly unpredictable and random mobility behavior within the network. Moreover the techniques in MANETs are based on broadcast method [6].

There are many cache invalidation schemes for mobile ad-hoc networks as well as for Vehicular ad-hoc network]7][8][9]. To take into consideration a few ,

cooperation techniques have proven to be far better than others in terms of reduced latency up-to certain extent[25][26][27][28].

II. SYSTEM MODEL

As shown in Fig. 2, iVANET is follows up a hierarchical network models where the components of network, say Vehicles, AP's, GFA's, HA's and Data Servers, shares a hierarchical relationship among them. Vehicles equipped with OBUs communicate directly to other vehicles as well as nearby APs using DSRC[4] enabled devices in line with IEEE 802.11 standards.

Vehicle's OBU is fully featured with capabilities like location awareness, built-in navigation system using GPS services, identifying and showing road around instant location and direction, sensing traffic condition, measuring lane margin, transmitting and receiving of data etc.

Unlike MANET environment, vehicles are restricted to move along the road path either in X-direction or in Y-direction under the imposed speed limits as well as rules of traffic lights on road. Thus, it is pretty calculative to predict a likelihood movement of vehicles.
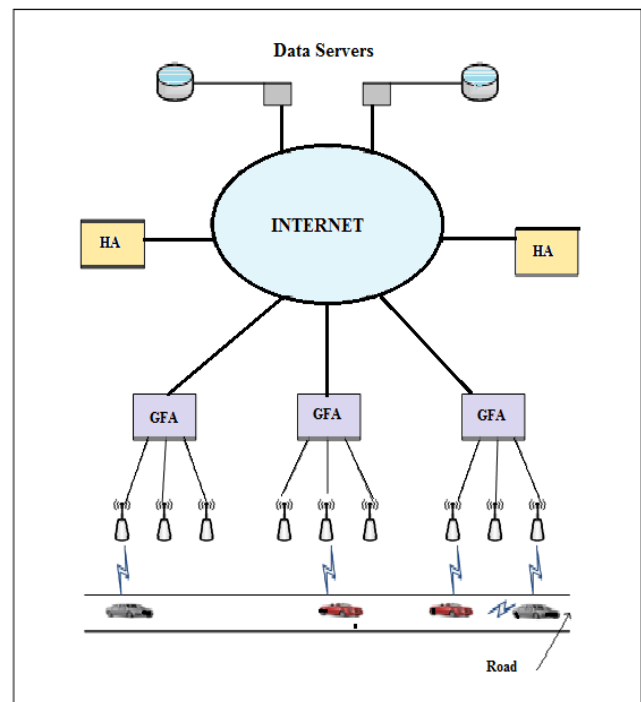

Fig.2 (*System Model*)

Considering a VANET scenario, a vehicle may be heading towards north direction on road which doesn't have any exit point, U-Turn or Crossing-Point up-to a number of kilometers ahead.

III. PAST RELATED WORK

Having gone through numerous literature reviews and work done in the past it is pretty good to say that numerous cache invalidation strategies are proposed, implemented and validated in copious literatures, mostly were based on validation report eg; Invalidation Report(IR-based validation) [11][12][13][14].

In IR schemes, servers use to send intermittent IR broadcast, which include updated and validated data items whilst moving nodes, which receive the IR, invalidate the cached data items.

In a scheme introduced by Sunho Lim et al[10] where, using mobile IP, triangular routing system were anticipated. In this approach vehicle's mobile-IP is used to deliver the packet and IR rather than broadcasting it blindly to all nearby nodes.IR report is also sent asynchronously to the Home agent. Using the same method, triangular routing approach, the HA prudentially redistributes the IR to concerned GFA. Within the same regional area, vehicle's location update is made at GFA while in a different regional network of vehicle, the same

is updated at HA so that packet could forwarded correctly thru the most appropriate GFA and AP.

An author proposes, in a work, an Aggregate Cache based On Demand (ACOD) scheme for cache invalidation by altering two existing schemes modified timestamp scheme (MTS) and updated invalidation report scheme UIR respectively which (MTS + UIR) resulted in ACOD strategy.

ACOD scheme proved to be efficient providing high throughput, reduced latency, and little communication overhead in iMANET environment [10][15][16]. Meanwhile in this proposal the security governing privacy still remains an issue which could be addressed by Privacy Enhancing Communications Schemes [17].

In an another work 3 Caching strategies eg; **POD** (Pull on demand), **MAT**(Modified Amnesic Terminal) & **PAT**(Pull Based Amnesic Terminal) schemes were proposed [20][21][22] which inherits their own pros and cons on different parameters of concern.

POD: In this method query delay was a bit low but the cache hit ratio was compromised and also the cost of query was soaring.[18]

MAT: It has shown a higher cache hit ratio and reduced query message cost, but it faces increased query delay [19].

PAT: It doesn't have much with novelty but nonetheless succeeded to maintain delta-consistency of recently cached data item [20].

The same was carried out along with a simple search (SS) algorithm ensures that a queried data is obtained from the closest AP or MP[23].

In a work of Sunho lim et al [24] an Aggregate Caching scheme has been proposed which puts together the local cache of every individual user (Mobile Terminal), like an unified cache, and tried to assuage the limited data accessibility and prolonged latency problems.

Few other approaches for cache invalidations were suggested by Sunho Lim, Chansu Yu† Chita R. Das[24][25[where they proposed a novel caching scheme, and an extended asynchronous (EAS) scheme in line with these two schemes. Authors proposed a state-aware cooperative cache invalidation schemes along with hierarchical network model where network-server and network-agents use to manage the IR operation.

The CCI (mobility impact on the performance is reduced) and ECCI schemes have achieved better performance than the others in terms of query latency, cache hit rate, and communication cost overhead.

Continuing the analysis of various schemes, in a work[26], where 3 methods have been designed and introduced by authors eg; **CacheData, CachePath and HybridCache.**

In first scheme (Cache Data), intermediary nodes use to store the most frequently accessed data in its cache memory so that future queries could be satisfied instantly by looking up rather seeking data onto remote data servers. This works fine in reducing latency when a cache hit is made during query request.

In second Scheme (Cache Path) nodes, cooperating the query requests, store path instead of queried data item so that the future queries could be well directed along the cached path to the most promising neighboring node having queried data item rather redirecting to remote data servers [27].

Finally the third approach (Hybrid-Cache) puts these two schemes (cache path + Cache Data) together to leverage the maximum out of it. This scheme exhibited a reduced latency as well as reduced message complexity on being compared with its contemporary caching algorithms (eg; Simple Cache And Flood-Cache).

While having been studied above many schemes cache cooperation still have not achieved a remarkable improvement in the query latency reduction. Continuing this effort, Rajeev Tiwari et al [28] have introduced the concept of cache cooperation at gateway components in iVANET and termed it "Cooperative Gateway Cache Invalidation Scheme for Internet-Based Vehicular Ad Hoc Networks". The designed scheme introduces the concept of placing caches at gateways along with the vehicle's cache as well as cache within AP's. The proposed scheme resulted in achieving good results and reduced query delay.

In another work of the same author "Rajeev Tiwari" et al [29] cooperation of gateways, within diverse regions of autonomy, concept was introduced with existing location management strategies. This concept proclaimed that it would require lesser no. of broadcasts as the probability of cache hit will get increased by a significant margin(due to cache multiplicity within network) and thus would require less no of redirection of query request to the remote servers. In this scheme the rate of query request, update rate of object, and the size cache have been the main parameters under the simulated environment and proven to the effective in terms of reduced query delay and increased cache hit ration.

IV.PROPOSED METHODOLOGY & ALGORITHM

This section first talks about the normal VANET scenario of query request-response approach and a slight glimpse of proposed methodology then it introduces its own algorithm(as proposed) named BCCI(Better Cache Content Invalidation) then it elaborates the approach used in algorithm. When a vehicle (V_y) request data item (d_x) which is not found in vehicle cache, then the requested query packet is forwarded ahead. This packet essentially contains 3 crucial information namely the id of vehicle itself, id-of requested data item and home address of requester vehicle to neighboring GFA's by AP, which checks for the cache validation. The id of queried data is compared with the vehicle registry (Rg.), if data is valid it sends the acknowledgement to vehicle, otherwise GFA sends this query packet to remote data server.

Fructifying the Network Performance of iVANET thru a Rectified Associative Service Mechanism: An Algorithmic Proposal

In addition to this we proposed the concept of vehicle position approximation by sending some additional information within query packet which we called **DVT** information. Where DVT is described as **Direction** of Vehicle, **Velocity** of vehicle and **Time-Stamp** on Query generation. So in the whole process of query packet forwarding components at each hierarchy in VANET, will be having piece of information regarding vehicle id, data-id, home network id as well as DVT. The algorithm works as explained below and our approach is also elaborated just after the algorithm.

A. Proposed Algorithm: Better Cooperative Cache Invalidation using Location approximation(BCCI)

Query_Request_Response(V_y, d_x, D, V, T)

1.　　Vehicle V_y requests the data item d_x　**// Searching Local Cache**
　　　{
2.　　*if* (data d_x is not found in V_y cache)　**//Search in range or nearby vehicles(V2V)**
　　　　{
3.　　Vehicle V_y sends the query request for data d_x to all adjacent vehicles and server.
　　　3.1　Adjacent vehicles perform BCCI lookup to their local CACHEs.

　　　3.2　*if (*adjacent vehicles do not find the data (d_x))

　　　　{
It forwards the requested data id to the concerned APs and GFAs for Cache admission control policy.
　　　3.3 Concerned GFA would receive and obtain the requested data from Data Server　and　call　response function:
　　　　RESPONSE_V( );
　　　　}
　else　　{
　　　If Data is found within the adjacent vehicles then these vehicles id's are grouped and prioritized according to the seek parameter using DVT (eg; distance from source, position within the network, direction and speed) Vehicle having top priority would be preferred to response the requested data.
5.　On receiving data, call procedure-

　　　　DATA_VALIDATION ( );
　　　}　　　}
6.　　*if* (vehicle found the data from the neighboring vehicle)
{　　Data is stored in cache and forward the acknowledgement to server so that server can stop sending the data any more.
　}
7.　　**else if** (data dx is found in Vy Local Cache)
　{
　　　Call　function-　**DATA_VALIDATION(　);**
//Vehicle send data id to GFA for data　validation.
　} }
}
8. Stop

Procedure: 1

RESPONSE_V( );

1.　Make location approximation to anticipate the current position of requester vehicle by estimating the Speed(**v**) and direction(**D**) of it after lapsing time "**t**".
　　Where-

$$t \quad = \quad T_{Current} - T_{Query}$$

$$v \quad = \quad \int_{0}^{t} dx/dt$$

$$d \quad = \quad v * (T_{Current} - T_{query})$$

$$X_v \quad = \quad X_{Curr} + d$$
$$Y_v \quad = \quad X_{Curr} + d$$

$$Direction = \begin{cases} +X \text{ or} + Y : & moving\ close \\ \\ -X \text{ or} -Y\ ; & moving\ away \end{cases}$$

$$\begin{matrix} Coordinate \\ Indicators \end{matrix} \begin{cases} X_n\ \&\ Y_n : Responding\ Entity \\ \\ X_v\ \&\ Y_v : Requester\ Vehicle \end{cases}$$

$$Loc\ Approximation = \sqrt{(X_n - X_v)^2 + (Y_n - Y_v)^2}$$

2.　If, as per approximation, Vehicle position is likely to fall in home network under the serving GFA)
　　{
　　　Forward the packet to the vehicle along the nearby AP.
　　}

3. **else**
　{

　　Make Location approximation using DVT to identify the expected GFA to be fall in the estimated location of requester vehicle after elapsing time **"t"**.

4.　Forward the response packet to this GFA for delivering the requested data to vehicle
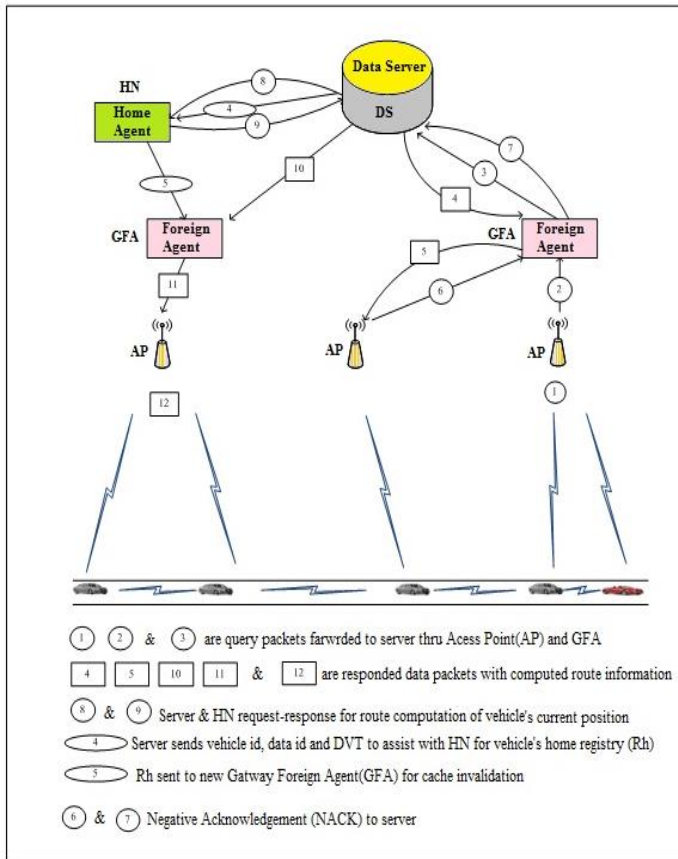
}

5.　**Stop**

Fig.3. (Proposed Scenario along with Service Mechanism)

B. Approach

In the proposed algorithm(BCCI), query packet includes additional piece of information. Since state-full servers are set free from location management task, the query pack needs to be well directed between sources to destination. For this purpose every packet will include the current **speed (v)** of vehicle, **direction (d)** of movement and the **timestamp (t)**.

In case of I2V communication the access point (AP) includes its own id along with DVT (direction, velocity & Time) information and the query message is forwarded to the Foreign Agent(In case AP's cache miss occurs). The GFA then further puts its own id along with DVT into the query message and finally the complete packet is sent to the data server(DS). In this way the packet would be consisting of information eg; id-Vehicle, id-HA, i-AP, id-GFA and plus DVT.

Using DVT parameter, at any point of time, the linear location of vehicle can be calculated an approximated after elapsing time *'t'* and so is the likelihood of befalling GFA or HA of vehicle. The server would also get to know the complete path of the requested query along the way it has reached to the server. The server will search the requested data and send back to concerned GFA using location approximation technique (likelihood of befalling). Server will finally suffice requested query of GFA. Also the server will be able to calculate and send the vehicle-id and the data id to the home network of the vehicle (a per calculation). Since Home Agent keeps a record of the vehicles passing thru its region, therefore it will deliver the request data item to the vehicle making request for it by comparing id-vehicle = id-data and at the same time its

registry will be updated accordingly. The GFAs will also work in same way. If the vehicle's motion is such that it doesn't cross the home network range then there is no problem but by time if vehicle would have crept into another network then the respective GFA will get to broadcast the packed responded by data server.

Hence this approach mitigates two of the challenges as discussed in problem statement. Firstly it reduces the cost of additional cache on GFA's & optimizes bandwidth overhead be setting off location management task. Secondly it reduces the negative acknowledgements by guaranteed delivery of query response packet to the vehicle.

This scheme holds an assumption that the location management task on stateful server is freed and vehicle position is approximated by each hierarchical component in iVANET.

V. RESULTS AND DISCUSSIONS

This section includes the performance of the proposed algorithm under simulated environment. An extensive simulation is made by setting various parameters like size of the network, size of the query packets, speed variation of vehicles, mean query generation time etc. The responses were recorded and statistical relations among output data values were established thru graph, bar chart and arithmetic calculations on tabular values.

A. Reduced NAC and Increased Throughput

Besides the proposed algorithm, other algorithm like CCI, EAS, ECCI were validated on the same parameters under our simulation.

Response	Local Hits		Remote Hits		Data Server Response	
	Hit	Miss	Hit	Miss	ACK	NACK
1	3	1	3	2	2/4	2
2	2	1	5	1	3/3	0
3	3	3	2	2	4/5	1
4	2	2	6	-	2/2	0
5	1	-	3	5	4/6	2
Total	11/5 =20%		19/5 =40%		15/5 =30%	90%

Table-1. NACK in the Network thru Data Server Response

The whole simulation set-up was run for 5 times and in each iteration 10 attempts were made to generate queries. Some queries resulted in local cache hit and some resulted in cache miss. Local Cache miss was responded by remote data server and achieved a remarkable 90 % successful query response. Only 10% NACK was recorded during the simulation trial.

If R_{totle} and $R_{sucessful}$ are the total no. of requests made and the no. of request successfully responded, then throughput Ø can be measured as-

$$\text{Ø} = (R_{suc} / R_{total})*100 \%$$
$$= ((11+19+15)/50)*100 \%$$
$$= 45/50$$

B. Mean Query Generation Time vs Cache Hit Ratio

Mean query generation time is varied from 10 ms to 200 ms and cache hit , cache miss is recorded along with NACK. If the query is replied by nearby vehicles, it's considered as local hit and if it is responded by AP, GFA/HA then it's considered as remote hit. If none of the case persist then query is responded by data server which may result in NACK or successful ACK.

Simulation statistics is illustrated in table-2 which helped in establishing relationship between mean query generation time and cache hit percentage.

Table-2: Mean Query Generation Time vs Cache Hit Ratio

Del ay	10		50		100		150		200	
S.N	Hit	Miss	Hit	Miss	Hit	Miss	Hit	Miss	Hit	Miss
1	6	4	8	2	6	4	8	2	2	8
2	7	3	7	3	7	3	4	6	3	4
3	5	5	3	7	2	8	2	8	5	5
4	8	2	6	4	4	6	6	4	8	2
5	4	6	4	6	4	6	6	4	7	3
Av g	60 %	40 %	57 %	43 %	54 %	46 %	52 %	48 %	50 %	50 %

During simulation, setup was run for 5 times and each time 10 attempts for data query was made which resulted in some cache miss and cache hit. The overall hit ratio was measured by taking an average of 250 attempt made for 5 successive mean time intervals.

Fig.3. Mean Query Generation Time Vs Cache Hit

In simulation the proposed algorithm performed better than others validated schemes and achieved fair cache hit than the rest. Fig-3 depicts the effect of mean query generation time verses cache hit. As per the simulation output, the Hit ratio is calculated as:

$$H = (H_{local}-H_{remote})/R_{total}) * 100 \%$$

$$= (60-30)/90*100$$

$$= 33.333\%$$

VI.CONCLUSION

As discussed in section 2, it is found that that, vehicular networks are being developed and are being improved by each passing day. Several new technologies and algorithms have been evolved and implemented which made VANET even more effective and usable by this new kind of communication network. While so many advancements have been made to VANET yet none of them can be proclaimed as foolproof and some way or the other they lack on different parameters like latency, throughput, bandwidth utilization, QoS etc.

So far we observed various state of art work, we found that the gateway cooperation technique [29] was though effective but has incurred in increased cost overhead and also there were plenty of –ve Acknowledgement(NACK) in the network which was lowering the effective bandwidth utilization of network. Latency and NACK have been the primary factor in our work for effective communication in VANETs. The latency in network is somewhat relative to the space faring away the data source and the remote vehicle as well as the mechanism involved in accessing source memory. Proposed algorithm has contributed to reduce the broadcast flooding between data source and the remote vehicle by using location approximation of vehicles and cache lookup mechanism which subsequently reduces the latency. Also by observing the vehicle's movements and direction a guaranteed delivery of data to vehicle is made possible which ultimately reduces the NACK to server and resulting in a high throughput.

This work includes both vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communication and proposed algorithm along with associative service mechanism for spotting out the vehicles thru DVT approximation approach and hence improvise the cache invalidation problem and negative acknowledgement (NACK) in iVANET. Also removing cache from gateways has lowered the cost overhead in VANET. Finally the proposed algorithmic solution(BCCI) has resolved these issues and hence came up with increased quality of service (QoS).

REFERENCES

1. Andreas Festag, , G. Noecker, M. Strassberger.., NoW - Network on wheels: Project objectives, technology and achievements. 5th International Workshop on Intelligent Transportation (WIT) . 211-216., 2008.
2. Tim Leinm¨uller+, Elmar Schoch and Christian Maih¨ofer, "Security Requirements and Solution Concepts in in vehicular ad hoc networks", Wireless on Demand Network Systems and Services, 2007. WONS '07.
3. W. Franz, H. Hartenstein, and M. Mauve, Eds., Inter-Vehicle-Communications Based on Ad Hoc Networking Principles-The FleetNet Project. Karlshue, Germany: Universitatverlag Karlsuhe, November 2005.
4. Qi Chen, Daniel Jiang and Luca Delgrossi, "IEEE 1609.4 DSRC Multi-Channel Operations and ItsImplications on Vehicle Safety Communications" Mercedes-Benz Research & Development North America, Inc. IEEE 2009.
5. Vehicular Ad Hoc Networks" University of Ulm, Institute of Media Informatics, pp. 103–112, 2007.D. B. Johnson, D. A. Maltz, and Y. C. Hu, "The dynamic source routing protocol for mobile ad hoc networks (dsr)," Published Online, IETFMANET Working Group, Tech. Rep., February 2007.
6. S. Lim, W. Lee, G. Cao and C.R. Das, "A Novel Caching Scheme for Improving Internet-based Mobile Ad Hoc Networks Performance," Ad Hoc Networks Journal, Vol. 4, No. 2, pp. 225–239, 2006.
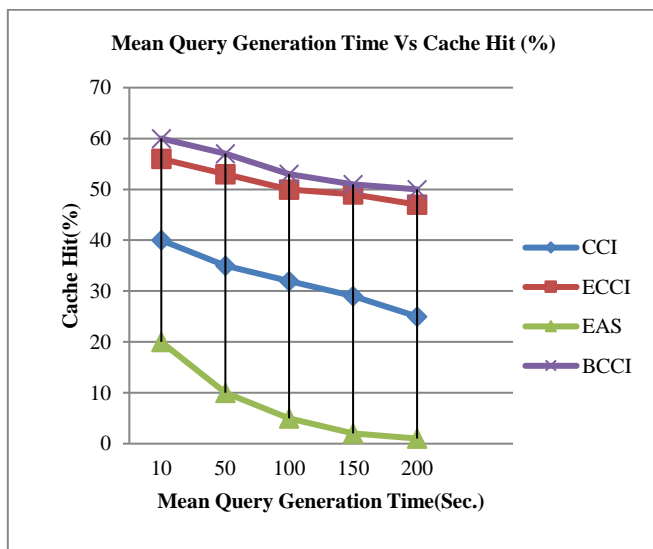
7. Nikolaos Frangiadakis and Nick Roussopoulos, "Caching in mobile Environments: A New Analysis and the Mobile-Cache System," The 18th Annual IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC), 2007.

8. S. Lim, W. Lee, G. Cao and C.R. Das, "Cache Invalidation Strategies for Internet-based Mobile Ad Hoc Networks," Computer Communications Journal, Vol. 30, No. 8, pp. 1854-1869, 2007.

9. Sunho Lim, Soo Roan Chae, Chansu Yu and Chita R. Das, "Cooperative Cache Invalidation Strategies for Internet-based Vehicular Ad Hoc Networks," IEEE International Conference on Mobile Ad Hoc and Sensor Systems, pp. 712 – 717, 2008.

10. Sunho Lim, Chansu Yu and Das, C.R., "Cooperative Cache Invalidation Strategies for Internet-Based Vehicular Ad Hoc Networks," IEEE International Conference on Computer Communications and Networks, pp. 1 – 6, 2009.

11. B. Zheng, J. Xu and D.L. Lee, "Cache Invalidation and Replacement Strategies for Locatio[1]n Dependent Data in Mobile Environments," IEEE Trans. on Computers, Vol. 51, No. 10, pp. 1141-1153, 2002.

12. G. Cao, "A Scalable Low Latency Cache Invalidation Strategy for Mobile Environments," IEEE Transactions on Knowledge and Data Engineering, Vol. 15, No. 5, pp. 1251-1265, 2003.

13. J. Xie, S. Tabbane and D. Goodman, "Dynamic Location Area Management and Performance Analysis," in Proc. IEEE VTC, pp. 536-539, 1993.

14. J. Xu, X. Tang and D.L. Lee, "Performance Analysis Location-Dependent Cache Invalidation Schemes for Mobile Environments," IEEE Transactions on Knowledge and Data Engineering, Vol. 15, No. 2, pp. 474-488, 2003.

15. Nicholas Loulloudes, George Pallis and Marios D. Dikaiakos, "On the Evaluation of Vehicular Communication Systems and its Applications," IEEE International Conference on Mobile Data Management, pp. 218-220, 2010.

16. Jose Santa, Antonio F, Go. Mez-Skarmeta and Marc Sanchez-Artigas, "Architecture and evaluation of a unified V2V and V2I communication system based on cellular networks," Computer Communications Journal, Vol. 31, pp. 2850-2861, 2008.

17. T.W. Chim, S.M. Yiu, Lucas C.K. Hui and Victor O.K. Li, "SPECS: Secure and Privacy Enhancing Communications Schemes for VANETs," First International Conference, ADHOCNETS, Vol. 28, pp. 160-175, 2010

18. Narottam Chand, R.C. Joshi and Manoj Misra, "Efficient Mobility Management for Cache Invalidation in Wireless Mobile Environment," Springer-Verlag 3741, pp. 536-541, December 2005.

19. Narottam Chand, R.C. Joshi and Manoj Misra, "Energy Efficient Cache Invalidation in a Mobile Environment," International Journal of Digital Information Management (JDIM) special issue on Distributed Data Management, Vol. 3, No. 2, pp. 119-125, June 2005.

20. Narottam Chand, R.C. Joshi and Manoj Misra, "A Zone Cooperation Approach for Efficient Caching in Mobile Ad Hoc Network," International Journal of Communication Systems, Vol. 19, No. 9, pp. 1009-1028, Nov 2006.

21. Narottam Chand, R.C. Joshi and Manoj Misra, "Energy Efficient Cache Invalidation in a Disconnected Wireless Mobile Environment," International Journal of Ad Hoc and Ubiquitous Computing (IJAHUC), Vol. 2, No. 1/2, pp. 83-91, 2007.

22. Narottam Chand, R.C. Joshi and Manoj Misra, "Cooperative Caching in Mobile Ad Hoc Networks Based on Data Utility," International Journal of Mobile Information Systems, Vol. 3, No. 1, pp. 19-37, 2007.

23. Narottam Chand, R.C. Joshi and Manoj Misra, "Data Caching in Mobile Ad Hoc Networks," In: David Tanier, ed. Encyclopedia in Mobile Computing and Commerce. USA: IDEA Group Publishing (IGP), 2007.

24. Sunho Lim, Wang-Chien Lee et. al. "A novel caching scheme for improving Internet-based mobile ad hoc networks performance" Ad Hoc Networks Volume 4, Issue 2, March 2006, Pages 225-239

25. Sunho Lim, Chansu Yu† Chita R. Das, "Cooperative Cache Invalidation Strategies for Internet-based Vehicular Ad Hoc Networks"

26. Prashant Kumar, Naveen Chauhan, Lalit Awasthi and Narottam Chand, "Proactive Approach for Cooperative Caching in Mobile Adhoc Networks," International Journal of Computer Science Issues, Vol. 7, No. 8, pp. 21-27, May 2010.

27. Liangzhong Yin and Guohong Cao "Supporting Cooperative Caching in Ad HocNetworks", National Science Foundation (CAREER CCR-0092770 and ITR-0219711-2011).

28. Rajeev Tiwari , Neeraj Kumar, "Cooperative Gateway Cache Invalidation Scheme for Internet-Based Vehicular Ad Hoc Networks", Wireless Personal Communications: An International Journal archive Volume 85 Issue 4, December 2015 Pages 1789-1814

29. Rajeev Tiwari , Neeraj Kumar, "Minimizing Query Delay Using Co-operation in IVANET", 3rd International Conference on Recent Trends in Computing(ICRTC-2015), 21 August 2015.

AUTHORS PROFILE

MOHD AKBAR, Assistant Professor, Thrust Area: Mobile Ad-hock Network, VANET, Mobile Computing, Cryptography & Network Security. Having 10 years of teaching experience in the Department of Computer Science & Engineering at Integral University, Lucknow.www.iul.ac.in, EMail: alakbar.com@gmail.com, Contact **:** +91-9335558865

Dr. Shish Ahmad, Associate Professor, Thrust Area: Network Security, Adhoc Sensor Network, Mobile Adhock Network, VANET. Having 17 years of teaching experience in the Department of Computer Science & Engineering at Integral University, Lucknow. www.iul.ac.in EMail: shish@iul.ac.in, Contact**:** +91-9453839087