Ad-hoc Network based Cache Invalidation Techniques in the Purview of Query Latency Minimization in iVANET: A Literature Survey

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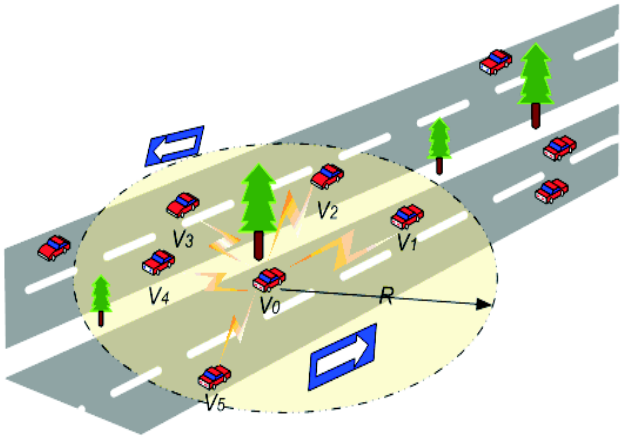
Abstract---- **Vehicular ad-hoc networks (VANETs) are an advance and challenging case of mobile ad hoc networks (MANETs). The main characteristic of vehicular networks is High speed dynamically changing network topology. The Internet Based vehicular ad hoc network (iVANET) combines a wired Internet and vehicular ad hoc networks (VANETs) for developing a new generation of ubiquitous communicating. The Internet is usually applied in vehicle to infrastructure (V2I) solution whereas ad hoc networks are used in vehicle to vehicle (V2V) communication. The latency is one of the hot issues in VANET which is proportional to the source-&-remote vehicle distance and the mechanism involved in accessing source memory. If the distance between data source and the remote vehicle is somehow reduced by using caching technique along with certain cache lookup mechanism, the latency is likely to be reduced by a significant factor in iVANET. In this Survey various cache invalidation schemes are studied and analyzed. The Survey aims at finding the possibilities of caching schemes which can be hybridized or muted in a way that may turn out to be novel than other existing schemes.**

Keyword--- ***Internet-based vehicular ad-hoc network, hybrid, cache invalidation, query latency, mobility, iVANET***

I. INTRODUCTION

Vehicular Adhoc Networks (VANETs) are an advance form of Mobile Adhoc Networks
(MANETs) which comprises of both wired and wireless technology. The communication takes place for inter-vehicle communication (V2V) and vehicle to Infrastructure eg; roadside unit(V2I) [3][31].
V2V deploys the wireless technology for Communication and the rest works on wired technology. However the connection among the roadside units is kept wired because the bandwidth of wired technology is still much higher when compared to that of wireless technology. The communication equipments used for the vehicle are known as "OBU" abbreviated as On-Board Units. OBU is capable of computing the data received, sense the environment and adapt to the changes accordingly while providing the information related to current position of the vehicle. On-board unit uses DSRC channel (Dedicated Short Range Communication) for communication [4]. The roadside unit is also based on DSRC channel and interact with vehicles at particular fixed point by the road side. The roadside units are basically governed and maintained by the government or a private vending agency which devise their protocols and incorporate in into the network.



V2V Communication Fig: 1[3]

The roadside unit possesses components eg; access point(AP), foreign agent (FA), home agents (HA) and the data server (DS). Road-side infrastructure (RSI) has short range communication capacity by which it communicates with nearby vehicles. All road side units (RSUs) are deployed in proper place in a given region. Initially the region may be small, but as technology and economic conditions mature, those regions can be interconnected to form a large region. Such an aggregation can convert districts to city or to a country and even to a global region eventually[1].

The roadside unit comprises of components namely access point (AP), foreign agent (FA), home agents (HA) and the data servers (DS). Access point acts as an interface

between the vehicle and the server. In order to connect to the server, the vehicle has to first contact the access point. Home agent (HA) is a router on a mobile node's home network that maintains information about the vehicle's current location, as identified in its care-of address. A home agent (HA) may work in conjunction with a foreign agent (FA), which is a router on the visited network.
An access point (AP) is a device that allows wired communication devices to connect to a wireless network. Data server is meant to provide accessibility to the data stored locally at various local servers. The Access point is used as an interface between the vehicle and the server. The vehicle has to contact the access point every time it wishes to connect to the server. Other elements of networks like Data server, Home agent and Foreign agent are purposely used to provide accessibility to the
data stored locally at different home agents(HA).
Like any other network, VANET has also been remain susceptible to many challenging issues namely, Routing, Security [2] and, Quality of Service issues like Query Latency time etc.

Routing plays an important role in VANETs applications but the high-speed mobility of vehicles and frequently changing topology results in conventional MANETs routing protocols which proves to be inadequate to efficiency and effectively deal with this unique vehicular environment as intermediate nodes cannot always be found between source and destination and end-to-end connectivity cannot always be established. This has led the researchers to find robust routing algorithms that are, good enough for the frequent path disruption caused by vehicle's random and quick mobility, new and novel approaches that can deliver improved throughput and better packet delivery ratio. Using the history based cache to store the movement information of inter-zone vehicles and location based information. 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]

VANET security challenges are yet need to be addressed in the fields of authenticity, confidentiality, and availability. A lightweight, scalable authentication frameworks are needed that are capable enough to protect vehicular nodes from inside and/or outside attackers infiltrating the network using a false identity, identifying attacks that suppress, fabricate, alter or replay legitimate messages, revealing spoofed GPS signals, and prevent the introduction of misinformation into the vehicular network. As far as driver confidentiality is concerned, we need reliable and robust secure protocols that can protect message exchanges among nodes of a vehicular network from threats such as unauthorized collection of messages through eavesdropping or location information (through broadcast messages).

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. Caching frequently accessed data is an effective technique to improve the network performance because it reduces the network congestion, the query delay and the power consumption [6]. There are many traditional Cache invalidation techniques which can be applied only in MANETs at present. These techniques cannot be adopted for VANETs because of the mere reason that VANETs deploy high speed random mobility in their infrastructure. Moreover the techniques in MANETs are based on broadcast method[6].
There are many cache invalidation schemes for mobile ad-hoc networks and Vehicular ad-hoc network]7][8][9]. To take into consideration a few , following are the various cache invalidation techniques this paper includes in the survey.

II. SYSTEM MODEL

As shown in Fig. 2, an IVANET comprises of access points (APs), gateway foreign agents (GFAs), home agents (HAs), and server of data item source. Vehicles are equipped with communication services such as an IEEE 802.11-based dedicated short range communication(DSRC) transceiver[4]. Using this, they can either communicate with other vehicles or can get connected to the Internet based network.[34][35] Since providing a location based capability in vehicles is becoming popular, it is assumed that vehicles are aware of its current location. Also vehicles have a built-in navigation system. A map is loaded using GPS system to show roads around current location and direction, the shortest path

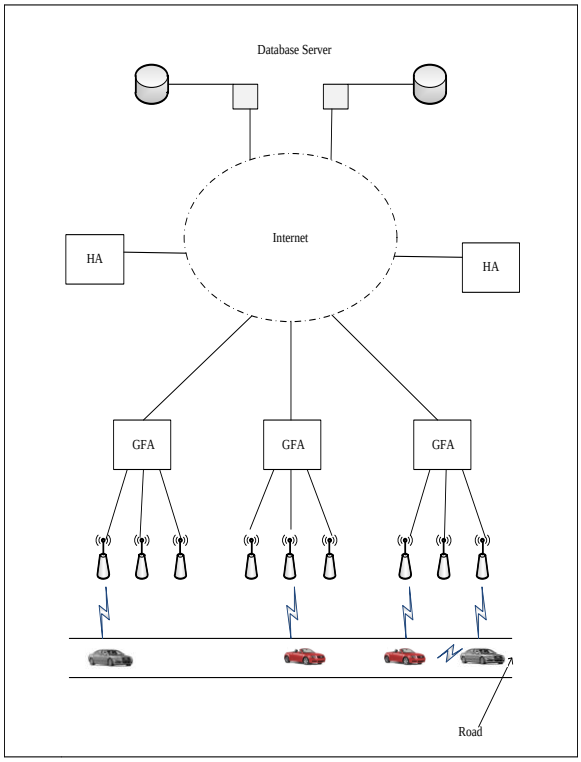


Fig: 2

to the destination, traffic conditions, location-dependent information, and so on. In addition, unlike cellular and MANET environments, where nodes move without restrictions, vehicles are bounded to the underlying fixed roads with speed limits and traffic lights in VANETS. Thus, it is quite simple to predict a likelihood movement of vehicles. For example, a vehicle is moving in the west direction along the road, while there is no exit or cross point for next several kilometers.

III. ANALYSIS: PAST RELATED WORK

A number of cache invalidation schemes have been introduced in numerous literature, all based on validation report eg; IR-based validation[10][11][12][13][14].

Server sends periodic broadcasts an IR, which includes a list of updated data items. Then mobile nodes (later in short, nodes) that receive the IR invalidate cached data items. An important design goal of these traditional cache invalidation techniques is to achieve a certain level of energy conservation, but it is not an issue in IVANETS because a vehicle is supported by its own built-in battery. Our concerns in developing a cache invalidation scheme in the context of IVANETS are mobility and cost of communication.

In another scheme by Sunho Lim et al[10] works on triangular routing system based on Mobile IP. They proposed cache invalidation scheme integrated with a mobile IP based location management. The server asynchronously sends an IR to a home agent (HA) rather than blindly broadcasts it to the vehicles. Then the HA judiciously refines and distributes the IR to appropriate gateway foreign agents (GPAs) based on triangular routing method similar to Mobile computing. When a vehicle moves into a coverage area within the same regional network, it sends the location update to the GFA.

When a vehicle moves into a different regional network, however, it sends the location update to the HA for correct forwarding the packets through the GFA and

AP. Both these schemes work take all the data as the same where as we classify the data into two categories and apply invalidation to both the data differently.

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

ACOD scheme proved to efficient providing high throughput, low query latency, and low 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 a classified work three Caching strategies namely **POD**(Pull on demand), **MOD**(Modified Amnesic Terminal) and **PAT**(Pull Based Amnesic Terminal)schemes were proposed [20][21][22].

Where

POD: query latency is low but the cache hit ratio query latency is low and the query message cost is high.[18]

MAT: Shows a higher cache hit ratio and lower query message cost, but it suffers from long query latency[19].

PAT: a pull-based strategy which only maintains delta-consistency of cached data[20].

In a work of sunho lin et al [24] an Aggregate Caching scheme is proposed which combines the local cache of each individual user (Mobile Terminal), like an unified cache, and tries to alleviate the limited data accessibility and longer access latency problems.

The same has been implemented along with a simple search (SS) algorithm ensures that a requested data is obtained from the nearest MT or AP.

Besides above mentioned schemes there are few more approaches for cache invalidations suggested by Sunho Lim, Chansu Yu† Chita R. Das[25] they proposed poll-each-read (PER) scheme, and an extended asynchronous (EAS) scheme. with reference to these two schemes, authors proposed a state-aware cooperative cache invalidation schemes along with hierarchical network model where network-server and network-agents coordinate the cache invalidation operation.

The proposed CCI (where the impact of mobility on the performance is minimized) and ECCI schemes provide better performance than others with respect to the query delay, cache hit rate, and communication cost overhead.

Continuing the analysis of various schemes , in a work, authors[26] have designed and proposed three schemes: CachePath, CacheData, and HybridCache.
In Cache-Data, intermediate nodes cache the data to serve future requests instead of fetching data from the data center.
The Cache-Path, mobile nodes cache the data path and use it to redirect future requests to the nearby node which has the data instead of the faraway data center [27].
Hybrid-Cache takes advantage of Cache-Data and Cache-Path while avoiding their weaknesses. Simulation results showed that the proposed schemes can significantly reduce the query delay when compared to Simple Cache and significantly reduce the message complexity when compared to 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 [31] has proposed Cooperative Gateway Cache Invalidation Scheme for Internet-Based Vehicular Ad Hoc Networks. It The designed scheme introduces the concept of placing caches at gateways along with the vehicles cache.
Doing so has an advantage of cooperation of Gateways in different regions along with the underlying location management scheme to reduce the number of broadcast operations, lesser Uplink requests, and query delay with an increase in the cache hit ratio. The query arrival rate, object update rate, and cache size has been the parameters of concern under the simulated environment and proven to the effective in terms of reduced query delay and increased cache hit ration.

The same authors have proponed another work of their whereby it is conceived that a state-full server have been included, which generates IR which is broad casted to HA which in turn unicast updated data to GFA and hence vehicle. This scheme uses cooperation of neighboring GFA which are storing hot data as fetched from server on any query reply. The proposed scheme works faster with cooperation of GFA, so queries are replied faster from cache or GFA
Furthering the ongoing research of the same authors Rajeev et al. have defined new heights of hypothesis regarding cache invalidation techniques and presented a work [36] called adaptive cache invalidation technique (ACIT). The proposed scheme uses different thresholds update rates for adaptive IR, and BT intervals. Only hot data updates in IR are recorded which results a less query delay, and bandwidth consumption. The scheme "ACIT" performs 150% better in query response time with a reduction in IR size to 25 % in comparison to other existing techniques (eg; CCI, ECCI etc.). Also, there is a reduction of 119.89 % in broadcast time interval using the proposed scheme.

Lastly the one more scheme of worth mentioning , proposed by Anurag Singh et al [37], is Enhancing Cache Invalidation Techniques in iVANET. In this work they have removed the concept of GFA from the network and defined a new hierarchy within the network. The location management work of GFA is now managed by Home Agents(HA). Each vehicle is identified by unique mobile ip imprinted on their OBU. By doing so the traffic on data server for location dependent data would now be reduced and eliminated by 60%(Hot Data is presumed to be only 60%) and hence the bandwidth utilization will get improved(specially in wired network system.
This scheme faces a pure assumption that the ratio of location dependent data and independent data is 40% to 60% respectively.

IV. CONCLUSION

So far literatures are reviewed and analyzed, it can be contemplated 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 enabled by this new kind of communication network.. The main focus in this survey was on Cache Invalidation techniques. There are an intense diversity in caching techniques. Query latency can be reduced in many ways. Some techniques rely on introducing improved hardware mechanism like enhancing cache size and increasing levels of cache memory in vehicles and other network components. Few other techniques uses algorithmic approach to bring about the efficiency in existing infrastructure on network. NC, EAS, PER, CCI, ECCI have found to be traditional caching schemes whereas hybrid caching, Gateway Caching using cooperation approach have found performing way better than the others. These techniques are also proven to be the state of art at present. Cooperation of caching at different level constituted a well established communication within least possible dilation in response but at the same time they compromises with the hardware cost and a boosted network congestion for location dependent data.

V. FUTURE WORK

Although several caching mechanisms have been studied and analyzed, some issues are still yet to be addressed. Though, out of many caching strategies , cooperative gateway caching technique have performed far better than others yet it lacks on increased cost , low bandwidth utilization and boosted traffic due to frequent query to data server and frequent lookups in GFA's caches.
So, theses issue could be addressed as future research challenge. Also, there is a fair chance of coming up with even better solution for reducing query latency using cache invalidation approach for above mentioned bottleneck of

CGCI (Cooperative Gateway Caching Invalidation) technique

(e.g. privacy problems due to radio frequency fingerprinting). Moreover, as different VANET protocols, mechanisms and applications are based on different architectures and assumptions, a common evaluation framework is needed to compare different security research contributions. Simulation results are often offered to evaluate current proposals. However, a common scenario to evaluate alternatives does not exist. Finally, hardware implementation of efficient cryptographic primitives is required in vehicles. In this way, achieving computation availability would be eased.

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