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Survey of Applications based on Vehicular Ad-Hoc Network (VANET) Framework

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Abstract- **Now-a-day's vehicle-to-vehicle and vehicle-to-infrastructure communication has become promising platform for highly mobile applications. Considering the impact of automobile industry, embedding software-based intelligence into vehicles has the power to drastically improve the user's quality of life. After understanding this impact increasing market demand for entertainment, security and reliability in automobiles has resulted in significant development and support of vehicular networks and applications. These emerging applications are spread across many fields from internet on wheels entertaining games, shopping to crime solving, etc. This paper presents a survey of such applications. Some of which are directly VANET based and some create their own network structure like VANET**.

***Keywords*: VANET, Ad hoc Network, vehicular ad hoc networks.**

I. INTRODUCTION

Recent advances in communication technologies have enabled wide range of networks. Vehicular Ad-Hoc Network is one of such network which has received lot of interest in last couple of years. VANET suddenly became an active area of development because of its immense potential to support whole new range of frameworks which will support applications to comfort drivers and passengers. Vehicular Ad-hoc networks are established between mobile vehicles equipped with wireless interfaces that could be either of heterogeneous or homogeneous nature [1]. VANETs (Vehicular Ad-hoc Networks) enable communication of one vehicle with another one as well as in between vehicles and nearby fixed roadside equipment. Vehicles and road side fixed equipment's both of them can be either private (belonging to individuals or companies) or public means of transport (like public service vehicles) service providers. In this network every participating vehicle works as single node or wireless router, allowing cars which are 100 to 300 m from each other to connect and create a network with a large range. As vehicles go out of the coverage range and get disconnected from the network, other vehicles can join, connecting vehicles to each another creating a mobile internet.

II. VANET ARCHITECTURE

VANET is basically combination of an on-board unit (OBU) and more application units (AUs) [1]. A device with communication capabilities placed inside the vehicle is known as OBU. An AU is a device executing applications by using OBU's communication capabilities. The both units of VANET are usually attached with a wired connection or wireless. The Ad-hoc domain includes vehicles equipped with on board units and stationary units placed along the road.

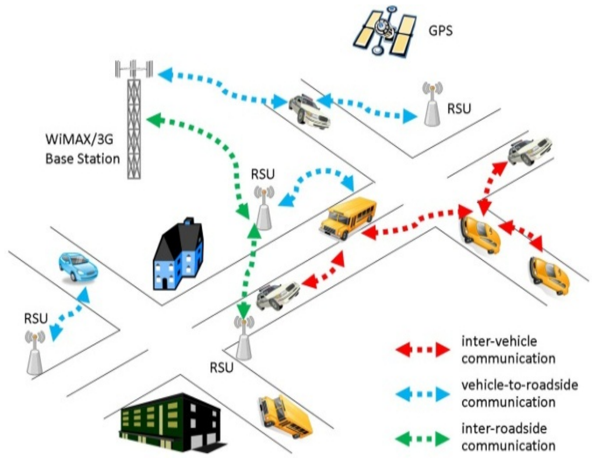

Fig. 1 VANET Architecture

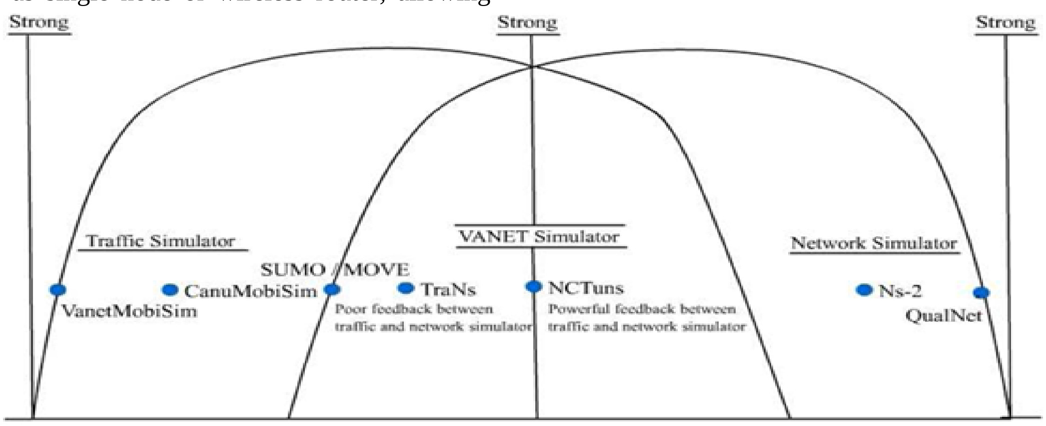

Fig. 2 Simulator Scenario

OBUs of different vehicles form a mobile ad-hoc network (MANET). On board unit and stationary road side device can be seen as nodes of an ad-hoc network. RSU can be attached to an infrastructure network, which in turn can be connected to the Internet. Road side stationary can also communicate to each other via multi-hop or directly. Their basic role is the improvement of road safety, by executing special applications and by sending, receiving, or forwarding data in the ad-hoc domain. Fig. 1 shows overview of VANET architecture [1].

III. VANET SIMULATION

While deciding simulator for simulating VANET applications presence of huge number of simulators creates problem. Simulator should be chosen by considering features of the VANET used in the application to be simulated. For example If the application needs to simulate larger number of nodes (more than 5000) then simulators like GloMoSim or QualNet should be considered as Ns2 or NCTUns will fail in that scenario. If applications need to use radio obstacles then VanetMobiSim or NCTuns are preferred simulators over SUMO, MOVE or TanNS. Fig. 2 shows comparison of different simulators [2].

Simulation of VANET takes place at two different levels, first is mobility generation and second is network simulation. First one is generally used to produce node movement traces that are then used by the network simulator. Network simulator also controls communication between the mobile nodes. As these network simulators support wireless communication, most of them include at least a simple node mobility model. Mobility models represent the movement of mobile users.

Tells about their location, velocity and acceleration change over time. The standard way to evaluate any new VANET concepts is to perform its simulation. The original objective of VANETs is to build safer roads through vehicular networks [2]. Another purpose is to provide internet connection for devices used by persons driving those vehicles. VANETs have opened many more doors and researchers have invented new concepts regarding how to apply this established technology of vehicular networks in various applications. This paper is about emerging body of work happening in the field of vehicular wireless connectivity and presents a survey of such applications whose framework is based on existing structure of VANET.

IV. SYSTEM ASPECTS

For reviewing different concepts this paper takes into consideration some aspects which might extract similar parameters among all these applications. The Core system aspect in all these applications assumes that there exist well implemented and running VANET structures in the area where this application will be used. Each application needs data acquisition and data delivery [3]. Data acquisition refers to the sampling of road traffic information by passing vehicles and data delivery refers to the propagation of traffic messages from the originating vehicle to one of the roadside units dispersed in the city or to some other moving vehicle. Every application has some real life sample examples which explain what actually the application will result into and in the end. It becomes necessary to evaluate benefits and limitations of applications under review. Some details about simulation setup required to simulate each application have been discussed.

V. VANET BASED APPLICATIONS

A. PeopleNet

PeopleNet [4] is an application which enables vehicles to form a virtual social network that mimics the way people seek information via social networking through direct contact. In PeopleNet, devices communicate with each other on behalf of their owners to communicate for exchange of needed information. At its heart, PeopleNet constructs a distributed geographic database. The information in this database consists of past queries placed by users from their mobile devices.

Consider working of PeopleNet through an example an individual who wants to buy/sell a ticket for a Wankhede stadium cricket game for which tickets are sold out can simply "post" a buy/sell ticket query near Wankhede Stadium. To allow the exchange of information over relatively large geographic areas, PeopleNet uses fixed infrastructure to post a query to its geographically pertinent place called a bazaar, e.g., the Wankhede stadium. Within this bazaar, it takes advantage of the *free-of-charge* but irregular interval connectivity provided by short-range radio technologies, such as Bluetooth, resulting in widespread queries dissemination. It means a query is propagated from one device to another without restriction whenever a wireless connection can "opportunistically" be query is propagated from one device to another without restriction whenever a wireless connection can "opportunistically" be established. If a match to the query is found, then the user who initially placed the query is eventually informed of the match (e.g., via e-mail or short message service).

The advantages of such a system are low communication overhead and if there are matching queries then guaranteed matches. PeopleNet is less efficient when it operates in a dense large-scale network, such as urban VANET scenarios, because the dissemination policy results in network-wide flooding.

In [4] for emulation purpose Nokia series 60 emulator was used and successfully tested it on Nokia 6600 phones. Paper [4] concludes that for PeopleNet application with infinite buffers random spreading is the right thing to do but for finite buffers it is not recommended as random swap is opportunistic. It insists exchanging some Meta-information prior to swapping queries. Our findings regarding meta-information exchange are that it does not consume significant system resources, but does yield significant gains in system performance. Results shows that this meta information helps the devices to make two decisions, namely, which queries to exchange with its neighbor and which queries to delete from its finite buffer.

B. FleaNet

FleaNet [5] is a virtual market service that works in an urban vehicular network to establish communication between buyers and sellers of goods or information and to effectively find matches of interest, potentially leading to transactions. FleaNet can be used for the retrieval of more generic location-aware (sensor) data, such as petrol prices or traffic information.

FleaNet [5] supports mobility-assisted query dissemination, where the query "originator" periodically advertises a query only to a two hop neighbors. Fig. 3 explains this query dissemination process graphically. Each neighbor then stores the advertisement (i.e., query) in its local database without any further relaying; thus, the query spreads only because of vehicle motion. For data delivery it uses two-hop multi copy protocol, which is a mobility-assisted data dissemination technique where only the source node copies a message to its direct contact nodes (i.e., to nodes within its communication range) and those nodes may then forward it to the destination node. FleaNet is based on urban vehicular networks in which vehicles communicate through a wireless interface, such as DSRC and 802.11p (WAVE). It uses query broadcast; a node (mobile/static) periodically broadcasts its query to its one-hop neighbors by default.

In [5] detailed simulation setup is given where each node is considered to have 802.11b connectivity, with a bandwidth of 11 Mb/s and a radio range of 250 m. For the radio propagation model, the two-ray ground reflection model is assumed. For realistic mobility generation, VanetMobiSim is used in combination with a Westwood vicinity street map obtained from the U.S. Census Bureau's TIGER. Result of simulation concludes that in most cases, a random query could be resolved within a tolerable amount of time. Paper [5] concludes that's for FleaNet model as the average speed or the number of nodes increases, the matching

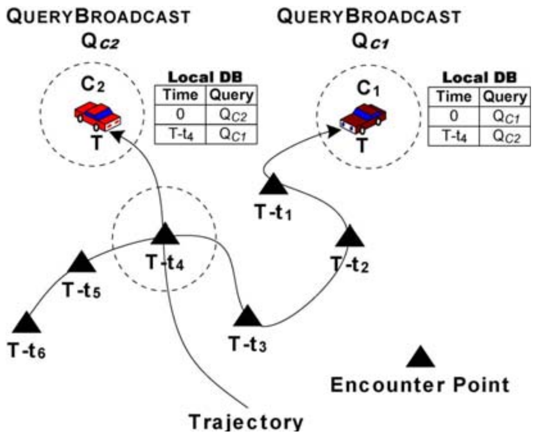

Fig. 3. Query Dissemination [5]

latency decreases. It brings a new parameter of query popularity where the latency improvement rate decreases in a relative way as the percentage of seller's increases and for FleaNet model the routing latency decreases as the node density increases. Churning is case where nodes move out of the network area (or out of the region of interest). As churning increases, for FleaNet according to paper [2] stationary nodes near the border area experience a much higher delay.

C. Adtorrrent

AdTorrent [6] proposes a novel push-model based location-aware ad service architecture, designed for vehicular environment. It is a system for content delivery, ranking and search in car networks. AdTorrent creates on the Digital Billboards, a scalable "push" model designed for ad content delivery. Static wireless digital billboards on the roadside are used for advertising. Digital billboards [4] only push advertising content to the vehicles passing by. Each node gossips about its content availability to two hop nodes in the range to facilitate the search.

Mobile users search for content of interest by querying neighbors (nodes in the range) via multihop querying and then download the advertising content. Adtorrent concept is elaborated via scenario; consider a person is driving on a road. Suddenly he remembers that he planned to buy some gift for his wife. He initiates a search for "new book releases". The Ad software is not only keyword aware but also location aware. Hence the search results return not only the content or latest book releases but also the latest deals on those book releases in nearby stores. Biggest benefit of Adtorrent [6] is it allows a node to download from multiple sources in parallel. Problem with Adtorrent is that when a network suffers from intermittent connectivity, such multihop querying or downloading may not be feasible. The overall download delay could be very large as a user has to encounter other users with data of interest.

Adtorrent uses a "real track" based group mobility model (RT model) that closely approximates the "heterogeneous" mobility patterns. For Adtorrent paper [6] proposes a special data structure called a bloom filter is used for storage and query resolution. Paper [6] presents a realistic mobility model for the urban, vehicular scenario and an analytical model of the epidemic query dissemination to evaluate the impact of the scope of the query dissemination on the hit rate. Model uses cache for memorizing queries within the network. LRU (cache management policy) is used. Paper concluded query hop limit of four will yield satisfactory performance in the dense urban scenario irrespective of the cache size.

***D.** MobEyes*

MobEyes [7] is a powerful support for urban monitoring based on the exploitation of vehicle mobility to opportunistically diffuse summaries about sensed data. In MobEyes system sensed data stay with mobile monitoring nodes. Vehicle-local processing is exploited to extract features of interest such as license plates from traffic images. MobEyes VSN nodes generate data summaries with features and context information which includes timestamp, positioning coordinates etc. Then, MobEyes collectors for example police patrolling agents move and opportunistically harvest summaries from neighbor vehicles. Collectors use summaries to identify data and then pump out only the sensed data of interest from the carrying vehicles. Applications of MobEyes can measure pollution and collect traffic information, such as road conditions and congestion.

MobEyes [7] concept is based the MobEyes Diffusion/Harvesting Processor named as MDHP. It works by opportunistically disseminating/harvesting summaries produced by the MobEyes Data Processor (MDP). MDP can access sensor data via uniform MobEyes Sensor Interface (MSI). MDP is in charge of reading raw sensed data via MSI, processing them and generating summaries. Summaries include context metadata and features extracted by local filters. Fig. 4 shows MobEyes architecture.

In MobEyes [8] two different types of passive diffusion are implemented. Single hop passive diffusion and second is k-hop passive diffusion where controller decides what value of k

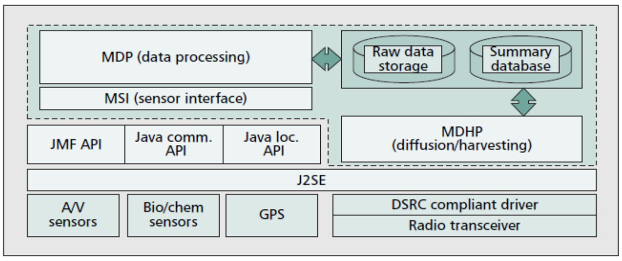

Fig. **4** MobEyes Architecture

will be. A MobEyes police agent [7] then performs collection of diffused summaries by proactively querying its neighbor. The ultimate goal is to collect all the summaries**.** MobEyes is simulated using ns-2 in [7] and [8], the adopted mobility model is Real- Track (RT) [10], which can represent urban mobility more realistically and using simulation [7] demonstrates the feasibility of autonomous VSN-based smart mobs for proactive urban monitoring, if coupled with lightweight mobility-assisted opportunistic protocols for summary diffusion/harvesting. Evaluation of MobEyes in [7] is done on its feasibility of summary harvesting latency, that is, the time for an agent to harvest all summaries generated by regular nodes. It shows that for MobEyes harvesting latency decreases as node density increases.

VI. Vehicular Network Based Applications

Now days, the commitment of wireless communications to support vehicular applications generated several research projects around world: In US, FCC allocated DSRC spectrum to “enhance traveler safety, decrease fuel use and pollution, and continue to advance the nation's economy”.

A. 911-NOW: A network on wheels

It is a mobile network for emergency response and disaster recovery operations based on proven air interface technologies and all-IP networking [9]. It is a new mobile cellular system based on stationary routers (BSRs) that are not dependent on any pre-existing wireless infrastructure and supports capacity and coverage on demand. 911-NOW is auto-configurable system with a fully integrated structure that can considered as a single- cell answer for communication or be configured to work as an ad hoc network of cells. Differentiating features of 911 NOW are wireless mesh networking, automatic configuration, interoperability with existing safety systems and network management. Let’s understand working of NOW [9] through a sample scenario. First responder units deployed around the emergency site communicates central database located at the emergency. Figure 5 provides a view of communication paths from a mobile unit to headquarters (or any host connected to a private or the public Internet) Fig. 5

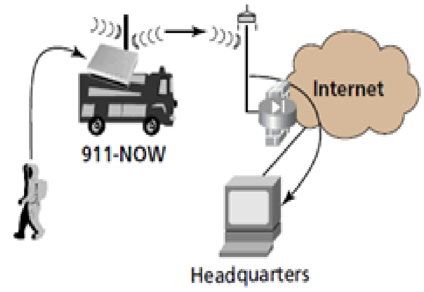

Fig. 5 911 Now [9]

depicts a single hop in the wireless backhaul; the wireless backhaul link is based on a microwave backhaul.

B. Electronic Preview Mirror (EPVM)

The current generation of ACC (autonomous cruise control) sensors only tracks the next vehicle in front to deduce its speed and position. This information is then used to regulate, measure, and reform a secure and safe distance between vehicles, indirectly providing some assistance to vehicle drivers. Electronic preview mirror [10] is added cost-efficient solution to existing basic ACC sensor function. It simultaneously provides a vehicle to vehicle radio communication. This millimeter wave sends required broadband perception data (video, localization) to vehicles ahead.

EPVM uses a unique sensor and realizes the ACC or anti-collision radar function also V2V wave communication link [10]. This radio link broadcasts broadband frontal and lateral perception data to the following vehicles. It is proven that the under-car microwave radio path is effective in transmitting information to the following vehicles. Fig. 5 shows Electronic preview mirror (EPVM) graphically [10].

A. *VGrid (Vanet GRID)*

VGrid [11] is fully-distributed traffic monitoring and control system in which each vehicle shares their positional and sensor information with their neighbors in order to collectively change their traffic flow patterns dynamically. It is a grid formed by considering inter-vehicle mobile wireless communications. The problem of smoothing vehicular traffic flow is solved via use of real-time velocity and position data exchanged over the network. This is done via accident alert messages sent from the site.

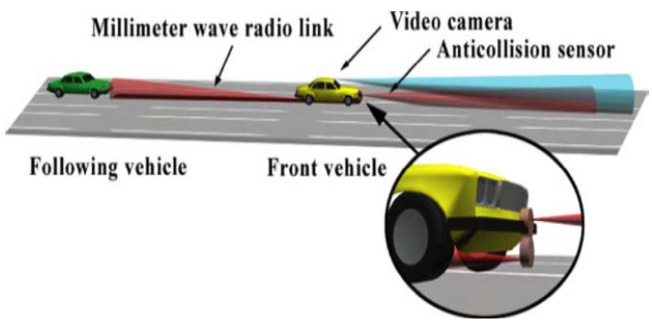

Fig. 5 Electronic preview mirror (EPVM)

VGrid can help locate accidents and decrease congestion through traffic monitoring and early alert messages also used to exchange information among vehicles to perform distributed computation to control or smooth traffic flow. Simulation is done using Java-based simulation tool based on the Cellular Automaton Traffic Simulators applet developed by Kai Bolay Mobility model used Nagel and Schreckenberg (N-S model). It basically studies effect of transmission range and penetration rate on VGrid. Paper [11] shows that penetration rate decrease as the percentage of participating vehicles increases and increased transmission range proves to be a benefit for knowing about an accident from very far away since it may not affect traffic at that distance.

B. VGITS (ITS based on inter vehicle communication networks and grid technology)

This technique [12] adopts hybrid architecture, and distinct real-time traffic services are provided in a centralized or decentralized way. It integrates heterogeneous software and hardware resources and presents the support for massive traffic data processing and real-time diverse traffic service presenting.

Grid technology is introduced to provide the efficient performance computing platform for massive traffic data processing and real-time traffic service presenting. The computation and communication capacity of the IVC network is developed and exploited to provide decentralized traffic services to drivers. Therefore, the system load is balanced among grid nodes and in-vehicle terminal, and better performance is achieved. In [12] not simulation but the prototype system is implemented to demonstrate the effectiveness and efficiency of VGITS.

*C. VMesh (*vehicular wireless mesh)

A group of nodes form a vehicular wireless mesh (VMesh) network [13] that can serve as an intelligent mobile transit network as well as a dynamic fleet of 10 distributed sensors. A mesh network is an ad-hoc network with no centralized authority or infrastructure. Nodes can move, be added or deleted, and the network will realign itself. VMesh is used to connect the disjoint patches of sensor networks. Individual VMesh nodes can serve as mobile routers to allow faster dissemination and retrieval of information among a huge number of sensor nodes. The gathered data can then be *deflected* among VMesh nodes and routed towards the destination.

VMesh is simulated by considering a 40 x 40 grid network, where sensor nodes are randomly located in a uniform distribution. The mobile routers are placed randomly and follow a random walk mobility model. There is one central collection point (CCP). When the mobile routers are within the transmission range of the sensor (or collection point), it will collect data. Two scenarios are investigated as no communication between mobile routers (NOTALK), and deflection routing using BROADCAST method. According to results in [13] the data delivery latency decreases when transmission range increases, since the number of hops required to reach the central collection points reduces. However, latencies decay and saturate much faster for BROADCAST strategy.

D. Contact Opportunity

It is basically about deployment techniques for providing roadside Wi-Fi services. Contact Opportunity [14], is a characterization of a roadside Wi-Fi network. The contact opportunity measures the fraction of time or distance that a vehicle user is in contact with some road side units when moving through a certain path. It models a road network as a connected geometric graph following two baseline algorithms is used: Uniform Random Sampling and Max-Min Distance Sampling. It is about creating powerful communication tool over roads.

VII. COMPARISON

This paper reviewed total nine applications. Four of them are directly based on existing structure of VANET and remaining five are able to create their own network similar to VANET to support applications designed for vehicles.

All these techniques reviewed are useful for different kinds of applications and different real life scenario. Adtorrent basically deals with strictly non real-time data where FleaNet and PeopleNet deal with real time data. In PeopleNet, FleaNet and MobEyes freshness of data matters a lot. All these techniques sometime suffer from intermittent connectivity due to vehicular motion and wireless mode of communication. In Adtorrent the overall multihop querying/ downloading delay could be very large as a user has to encounter other users with data of interest.

As in Adtorrent communication between vehicles is over a low data rate connection but in PeopleNet due to limited area or bazaar high data rate connection have higher possibility. In case of Multi-hop delivery, in Adtorrent is infeasible to transmit data to more than a few hops. In MobEyes application do not concentrate on multi hoping as single police agent is responsible for data collection. In many ways FleaNet extend features of PeopleNet as FleaNet uses DSRC/WAVE, not used in PeopleNet so it provides extended geographic coverage and faster mobility for vehicles. PeopleNet depends on infrastructure support but MobEyes, FleaNet and Adtorrent can operate without any infrastructure support because it uses inter vehicular communication for query dissemination, matching, and notification.

VIII. CONCLUSION

This paper surveyed the emerging vehicular applications, ranging from vehicular transactions to entertainment. Paper presented various simulation tools that are available for VANET simulations and were used to test all these applications. Taxonomy on applications will be helpful to future VANET researchers while designing applications to improve comfort for human life.

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