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Detailed Comparative Study of Various Routing Protocols in Vehicular Ad-hoc Networks

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Abstract— Vehicular Ad-hoc Network (VANET) has become a research area for analysis and development. VANET is a subclass of MANET (Mobile Ad-hoc Networks), which provides a communication among nearby vehicles and between vehicles and nearby fixed infrastructure. VANET is different from MANETs in terms of high mobility and dynamic topology. Maintaining High mobility and information routing in VANETs is very difficult and challenging task. Key characteristics of VANETs are time-varying nature of vehicle density, time critical safety applications, self-organizing, distributed communication, road pattern restrictions and high mobility. Sudden change in network topology and sporadic connectivity are also the characteristics of VANET. VANET provides facilities regarding road safety, traffic management, internet access, map location, for passengers and drivers. In this paper we describe a brief overview on some topology based protocol: proactive routing protocol and reactive routing protocol.

Keywords— MANET, VANET, Routing Protocols, Proactive Routing, Reactive Routing, WAVE.

INTRODUCTION

A Vehicular Ad-hoc Network (VANETs) is a special case of MANET, which aims are to reduce congestion, optimize traffic flow and to improve road safety. VANET is autonomous and self-configured communication network, where nodes act as a server and/or clients for sharing and exchanging information. There are many difficulties in VANETs system design implementation, regarding: security, routing, privacy, connectivity and quality of services (QoS) [2, 3]. One of the outcomes to avoid bad traffic areas has been a novel type of Wireless Access for Vehicular Environment (WAVE) for Vehicle-to-Vehicle (V2V) and Vehicle-to-Roadside (V2R) communications. WAVE standards based on the emerging specification IEEE 802.11p. This paper will focus on routing problem and the main goal for routing protocol is to provide optimal paths between network nodes via minimum overhead.

This paper divided into five main sections where section 1 provides general introduction to the VANET, Section 2, describe the network architecture and characteristics. Section 3 provides the brief introduction to the different routing protocols with their pros and cons. Section 4 introduces the literature survey on VANET taken from various papers. At last Section 5 concludes the paper.

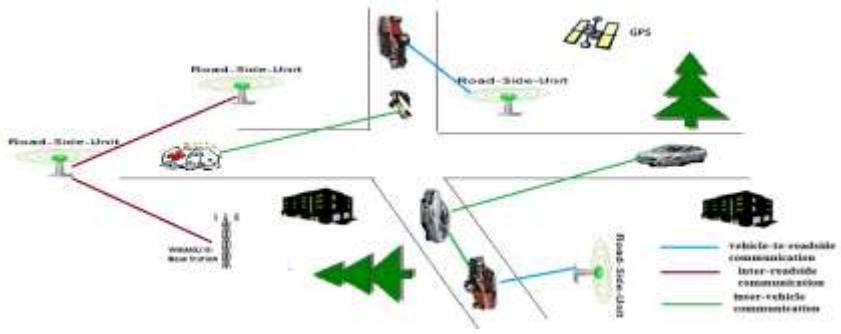


Figure 1: VANET

1. VANET ARCHITECTURE AND CHARACTERSTICS

Wireless Ad-hoc network do not depend on fixed infrastructure for communication and dissemination of information [1]. Vehicular networks are composed of vehicles equipped with On Board Units (OBU), mobile nodes and stationary nodes called Roadside Units (RSUs). OBU communicate with RSUs in ad-hoc manner. Dedicated Short Range Communications

(DSRC), enhanced version of Wi-Fi technology is developed to support data transfer in rapidly changing communication environments, where high data rates and time-critical responses are required [11].

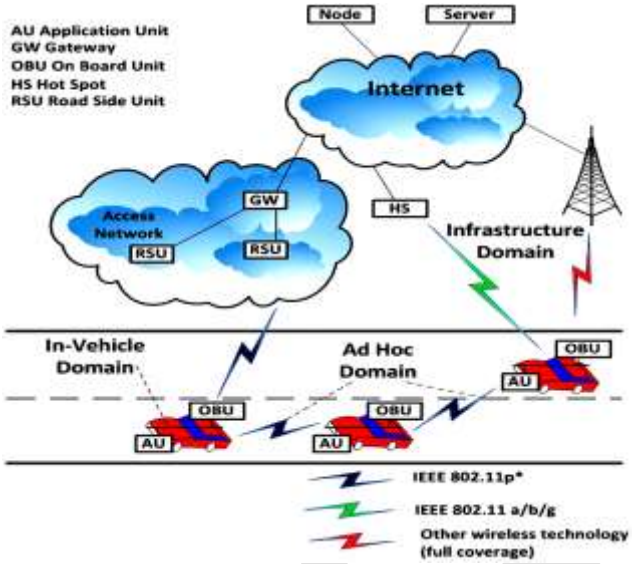


Figure 2: VANET Architecture

VANET Characteristics:

VANET are characterized by high relative speed means high mobility and are governed by restricted rules. Frequent network topology changes reduce overhead for exchanging new topology information. Safety messages which are the main goal of VANET must be delivered on time and vehicles use GPS (Global Positioning System) with great accuracy in VANET [11].

2. ROUTING PROTOCOLS

Routing protocols ensure that information is exchange between entities, and follow the procedure in establishing a route, decision in forwarding and covering or maintaining from route failure. These protocols are classified on the basis of area/application: Topology based routing protocol, cluster based routing protocol, position based routing protocol, and Geo cast routing protocol and broadcast routing protocol. We only study Topology based Protocols:

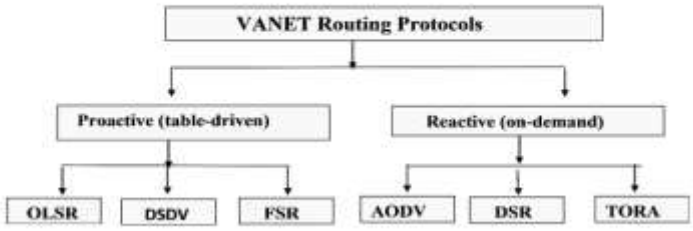


Figure3: Routing Protocols For VANET

2.1 TOPOLOGY-BASED ROUTING PROTOCOL

Topology-based routing protocol uses link's information about the network topology, which stored information in routing table to forward packets from source to destination [11]. They commonly categorized into Proactive (periodic or table-driven), Reactive (On-demand) routing protocols.

2.1.1 PROACTIVE ROUTING PROTOCOLS

There is no route discovery in table-driven (Proactive) routing protocol. It has the following features: such as the next hop used is maintained in the background irrespective of communication requests. As the network topology changes, the table must be updated frequently and should be broadcast to the neighbors periodically [5,6,9].

Pros:

i. No route discovery is required.
ii. Low delay in real time application.

Cons:

i. Overhead increases in periodically sharing tables.
ii. Significant part of available bandwidth is wasted.

2.1.1.1 DESTINATION SEQUENCE DISTANCE VECTOR ROUTING(DSDV)

DSDV is based on the Bellman-Ford algorithm and it is a table-driven routing scheme. It uses a shortest path algorithm and it implements the distance vector strategy and used only one route to destination which stored in routing table. All information about all accessible network nodes is stored in routing table and each entry in the routing table contains a sequence number initiated by the destination node. DSDV protocol control message overhead and guarantees the loop free routes and information is distributed between nodes by sending full dumps infrequently and smaller incremental updates more frequently[6,13].

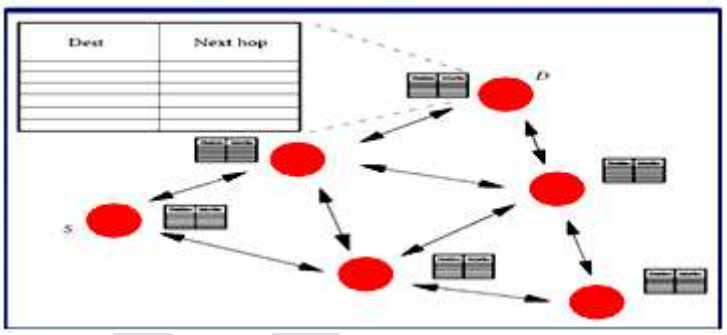


Figure 4: Routing in DSDV

Pros:

i. It generates a loop free path to the destination.

Cons:

i. Full dumps packets decrease the bandwidth because only updates are not sent the complete information.

2.1.1.2 OPTIMIZED LINK STATE ROUTING PROTOCOL(OLSR)

OLSR is a table-driven and proactive protocol, implements the link state strategy. Only symmetric links are used in OLSR for route setup processes and relays. Each node in the network must send its updated information to some selective nodes called as Multi Point Relays (MPR), which retransmit this information to its other selective nodes. The nodes which are not in MPR set can read and process the packet. MPRs are also used in route calculation to form the route from source to destination node. Protocol may cause network congestion and it uses the MPRs for efficient flooding of control messages in the network [13].

Pros:

i. It well works in high density networks.

Cons:

i. Requires a routing table for all possible routes, resulting constraints scalability and overhead.

2.1.2 REACTIVE ROUTING PROTOCOLS

Reactive routing protocols (also known as On-demand), reduce the overheads and saves bandwidth by maintaining routes only when needed. It offers high latency while finding the routes, is the drawback of reactive routing protocols. Unicast communication is used by destination node to send route reply message back to source node.

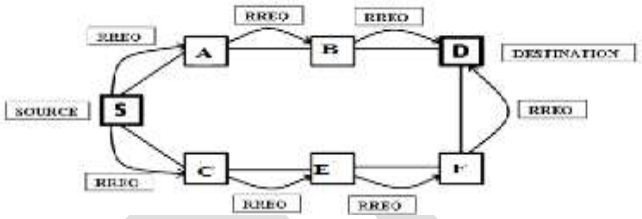


Figure5: Route Request Propagation in reactive routing protocol

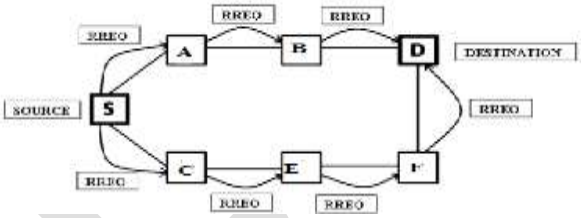


Figure6: Route Reply propagation in reactive routing protocol

Pros:

i. Beaconless, so it saves the bandwidth.
ii. Less overhead to update routing table. Flooding requires only when it is demanded.

Cons:

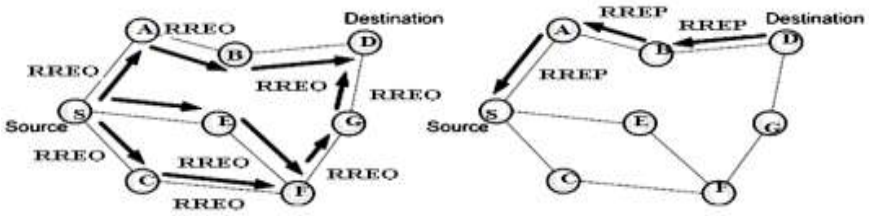
i. Latency is high for route discovery.
ii. Extra bandwidth is required for periodically sending beacon messages.

2.1.2.1 ADHOC ON-DEMAND DISTANCE VECTOR(AODV)

AODV [6,7,14,15] is a loop free protocol in ad-hoc network, reduces flooding in the network and provides low overhead as compared to proactive protocols. It causes large delays in a route discovery, also require new state information when a link gets failed and

notification is sent to the affected nodes. An important feature of this protocol is the maintenance of time-based states in each node is that a routing entry not recently used is expired.

The following messages are used by AODV: Route Requests (RREQ), Route Errors (RERRs), and Route Replies (RREPs). RREQ is broadcasted by a node requiring a route to another node. IP address is used as a source address, when it request for a route. A message RERR is generated upon failure of any link; RERR message contains the information of nodes, which cannot access due to this failure. HELLO messages are used for detecting and monitoring links to neighbors.



(a) **(b)**

Figure7: AODV route discovery process

Pros:

i. The path to the destination is updated because of using destination sequence number.
ii. Reduces route redundancy and excessive memory requirement.

Cons:

i. It takes long time for connection setup and establishment of route.
ii. Extra bandwidth is needed because of periodic beaconing.

2.1.2.2 DYNAMIC SOURCE ROUTING(DSR)

DSR routing protocol is reactive protocol, designed for multi-hop wireless ad-hoc networks. DSR has potentially more routing overhead than AODV because in DSR, data packets carry the full routing information as compared to AODV in which data packets contains only destination address [14, 7].

DSR follows two main approaches: Route discovery and Route maintenance. In route discovery, on requirement of a route a source node initially broadcast a route request message using a unique "Request id", address of source and destination. If an error is generated, source node should delete the failed route from its cache and initiate a new route discovery process.

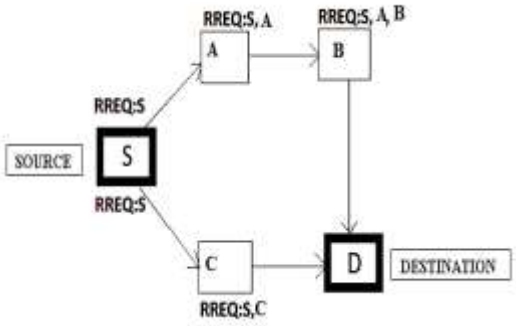


Figure8: Route Request Propagation in DSR

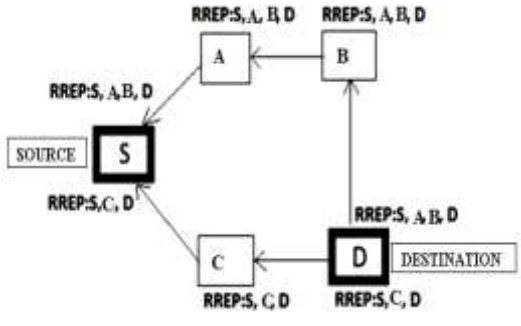


Figure9: Route Reply Propagation in DSR

Pros:

i. It uses caching to reduce load on the network.
ii. No periodic update is required in DSR.

Cons:

i. Unable to repair broken links locally.
ii. In high mobility it performs worse.

3. LITERATURE SURVEY

- Uma Nagaraj, Dr. M.U Kharat and Poonam Dhamal in [3] have studied various Routing Protocols in VANET. From this paper they concluded that Position based, Geocast and Cluster based Protocols provides more reliability in most of the applications in VANET.
- Aarja Kaur and Sabia in [18] have surveyed of various Routing Protocols in VANET. They studied that sudden changes and sporadic connectivity in network topology are the characteristics of VANET. The authors have observed that Routing Protocols works better only in some particular scenario like city, urban environment etc. A specific Routing Protocol needed to fulfill the requirements of a particular VANET application, because still there is no universal protocol which is comfortable or suitable with all VANET's application scenario.
- Ginni Tonk, S.S Tyagi in [19] used Network Simulator NS-2 to evaluate the performance of Ad-hoc Network Routing Protocols in different network sizes. The overall conclusion of this paper showed that in high network size DSDV gives highest PDF, Routing Overhead, lowest NRL and shortest End-to-End delay and provides highest Throughput while DSR gives Lowest Packet Loss. But in case of low network size; DSDV gives the lowest NRL, lowest Routing Overhead and shortest End-to-End delay, whereas DSR provides highest Throughput and gives lowest Packet loss.
- Prabhakar Ranjan and Kamal Kant Ahirwar in [1] compared VANET and MANET Routing Protocols and this paper showed that MANET Routing Protocols does not provide Optimum Throughput, i.e. required for fast changing topology in VANET. After comparison authors found that Protocols which are feasible for MANET also feasible for VANET but there performance varies with varying densities and traffic conditions. The result showed that AODV is best among the various Routing Protocols for both MANET and VANET and analyzed that very few Routing Protocols can be well suited for both the VANET and MANET.
- Sherali Zeadally in[12] studied about VANETs: status, results and challenges and present a review of Wireless Access Standards for VANETs and outlined some of the VANET research challenges like scalability, reliability, robustness, secure VANET architectures, Protocols, technologies and services. In this paper authors highlighted and achieved some salient results of security, routing, QoS and broadcasting techniques. They analyzed of various simulation tools that are available for VANET simulations.

Table 1: Comparison of VANET with MANET [20]

Parameters	VANET	MANET
Mobility	High	Low
Range	Up to 500m	Up to 100m
Reliability	High	Medium
Nodes Moving Pattern	Regular	Random
Bandwidth	1000 kps	100 kps
Density in Nodes	Frequent variable and dense	Sparse
Node Lifetime	It is depend on Vehicle life time	It is depend on power source

Table 2: Comparison of some popular Topology Based Protocols

Protocol	Routing Structure	Frequency of Updates	Advantages	Disadvantages
DSDV	Freeway	Periodic	Loop free	Knowledge required of 2 hops
OLSR	Freeway	Periodic	Improve the QoS, Reduce Network load, Reduce Contention	Optimal node is calculated
AODV	Freeway	Unicast & Multicast	Up-to-date information of paths, use in large area of network, reduce excessive memory requirement, responses to the link failure.	Connection setup takes more time; high bandwidth is required and creates inconsistencies in the route.
DSR	Freeway	Unicast	Periodically updating is not required, Beaconless, Caching approach is used which reduces load on the network.	Unable to repair broken links locally, unnecessary flooding and in the high mobility performance get worse.

CONCLUSION

We have considered various Routing Protocols in VANET. For all VANET applications it is very difficult to design an efficient Routing Protocol. This paper provides two categories of VANET routing protocols, giving a brief introduction with architectures and comparisons of Protocols working with their pros and cons. Packet Delivery ratio of AODV is better than OLSR,DSDV,DSR but fails in End-to-End delay where time is very short. Performance of OLSR is average. DSR works well in short time but loss of packet information is high. In this brief overview different related research limitations/difficulties are represented that require more efforts and research to address them. Privacy is a major issue which should be address and research the various approaches for QoS, security, reliability all are Routing related difficulties in VANET.

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