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A Study and Performance Analysis of TORA Routing Protocol in Vehicular Ad-hoc Networks

[1] R. Jeevitha, [2] K. Thilakavalli, [3]D. Rajagopal

[1,2] Assistant Professor, Department of Computer Applications, Karpagam University, Coimbatore, India
[3]Assistant Professor, Department of MCA, Vivekanandha College of Arts and Sciences for women, Tiruchengode, Namakkal Dt, India.
E-mail: [1]jeevitha3mca@gmail.com, [2]thilaksathya2782007@gmail.com, [3]sakthiraj2782007@gmail.com

ABSTRACT

Vehicular Ad-hoc Networks (VANETs) became very popular in few years and it has been widely used in research and industry communities. VANET is a collection of wireless vehicle nodes forming a temporary network without using any centralized Road Side Unit (RSU). VANET is a subset of Mobile Ad-hoc Networks (MANET). It improves the safety of vehicles. It also supports Intelligent Transportation Systems. Routing is the major component of communication protocols in VANETs. Packets are to be routed from the source node to destination node. Because of frequent topology changes and routing overhead, selection of routing protocol in VANET is a great challenge. There are various routing protocols available for VANET. This paper involves study of Temporally Ordered Routing protocol (TORA) and performance metrics are analyzed with the help of NS2 Simulator.

Keywords: *Vanet, Manet, Tora*

1. INTRODUCTION

Vehicular ad-hoc network is a form of MANET. Each and every node is considered as vehicles. It provides wireless communication among vehicles and vehicle to roadside equipment. The communication between vehicles is used for safety and for entertainments as well. The performance of communication depends on how better the routing takes place in the network. Routing of data depends on routing protocol being used in network. It allows an automobile to become both a wireless node and a router. It can communicate with each other, with roadside infrastructure nodes, which may, in turn connect to the internet, as well as with pedestrians equipped with wireless devices such as a smart phones or PDAs [1] [2].

Integrating a network interface, GPS receiver, different sensors, and on-board computer gives an opportunity to build a powerful car-safety system, capable of gathering, processing and distributing information. Numerous applications can be deployed in a network established with such equipped vehicles and proper infrastructure. Generally, from the connectivity point of view they could be divided into four main groups: car-to-car traffic, car-to infrastructure, car-to-home, and routing based applications. These applications are either safety related or comfort-related.

Absence of road traffic safety takes a toll of precious human lives and poses a dire threat to our environment as well. Other negative consequences are related to energy waste and environmental pollution. Various precautions like seat belt s and airbags are used but they cannot eliminate problems due to driver's inability to fore see the situation a head of time. On a highway, a vehicle cannot currently predict the speed of other vehicles. However, with use of sensor, computer, and wireless communication equipment, speed could be predicted and a warning message sent every 0.5 seconds could limit the risk of potential accidents [6].

The roadside elements such as road traffic signs or traffic lights typically just provide visual information and usually with an unchanging pattern. However, with the application of VANET technologies the roadside elements acting as RSU could be more active in informing users with personalized real-time information. For example, a dangerous curve sign could warn the driver of a vehicle traveling at excessive speed before reaching it. Another example would be men at work signal, which may broadcast information about of the existence of road works, so that drivers would know their existence in advance.

Basic applications are aimed at improving road safety (collision warnings, weather, and road hazard alerts) as well as providing driver convenience (notification of real time traffic information, parking availability, and location-based services). VANET research challenges include routing, security frameworks, Quality of Service, Broadcasting. Three major classes of applications possible in VANET are safety oriented, Commercial oriented, and convenience oriented.

2. CHARACTERISTICS OF VANET

VANET networks can be viewed as a subclass of MANETs where nodes are vehicles or roadside infrastructure elements. However, they behave fundamentally different. The mobility of their nodes is the main and most critical difference. The mobility of vehicles (nodes) that belong to a VANET is influenced by driver behavior, constraints on mobility (road restrictions), and high speeds. These characteristics have important implications for design decisions in these networks.

The characteristics of VANET includes high mobility of nodes, rapidly changing network topology, unbounded network size, Potential support from infrastructure, Real-time, time-sensitive data exchange, crucial effect of security and privacy.

Rapid changes in VANETs topology are difficult to manage. Due to high relative speed between cars network's topology changes very fast. VANET networks are subject to frequent fragmentation, so that messages have troubles reaching their destination nodes. Such networks have small effective network diameter. It is mainly due to the speed, the high number of obstacles, and the height of the used antennae. For this reason, links between nodes can be broken frequently. The devices used to deploy these networks have not significant power constraints, unlike sensor and other types of mobile devices used in other kind of MANETs where limited battery life is a major concern.

3. ROUTING IN VANETS

Message routing is a challenging problem in VANETs due to the inherent high degree of mobility of a large number of nodes. To enable message routing, the source node should be able to locate the destination node (node localization), and it can build a reliable route towards the destination node. VANETs can provide a viable alternative in situations where existing infrastructure communication systems become overloaded, fail (due for instance to natural disaster), or inconvenient to use.

The way, messages are routed between sources and destinations is considered to be very important. Without an effective message, routing strategy VANETs' success will continue to be limited. In order for messages to be routed to a destination effectively, the location of the destination must be determined. Since vehicles move in relatively fast and in a random manner, determining the location (hence the optimal message routing path) of (to) the destination vehicle constitutes a major challenge.

VANETs consist of mobile nodes having dynamic topology; hence, the mechanism of finding, maintaining and using routes for communication is not trivial for fast moving vehicles [5]. Short lifetime of communication link, less path redundancy, unpredictable node density, and strict application requirements make routing in VANETs quite challenging. In the related and similar domain of MANETs, there has been extensive research about the routing protocols during the past decade. Early VANET prototypes and studies have used MANET routing protocols as such, but later on, these protocols are adapted for the VANET environment.

Because of the fact that it may be necessary to send a packet through several vehicles to reach a determinate node a routing protocol is needed. Designing an efficient and reliable routing strategy is one of the most challenging problems in the field of VANETs. As these are wireless ad-hoc networks, all nodes behave as routers and take part in discovery and maintenance of routes to other nodes in the network. An adaptable routing strategy is required since network conditions change continuously such as: network topology, traffic density, and network partitioning. Additionally, the routing protocol may need to provide different levels of QoS to different types of applications and services.

There are different types of routing protocol in VANET such as proactive routing protocol, reactive routing protocol, hybrid routing protocol, topology based routing protocols, and position based routing protocols. Existing unicast routing protocols of VANET has some disadvantages and is not capable to meet every traffic on highway road scenarios [11].

Proactive routing tries to maintain routes to all destination. Reactive routing initiates route discovery in demand of data traffic. Position based routing is based on destination's position.

Since VANET is possessing a high dynamic topology, the existing routing algorithms in MANETs are not suitable for most of the application scenarios in VANETs.

A. *Pro-active routing protocols*

In proactive routing protocols, each node maintains routing information to every other node in the network. The routing information is updated in routing tables. Each routing protocol may maintain different number of tables. Proactive routingProtocols are also known as Table-driven protocols. DSDV and OLSR are the examples.

B. ***Reactive Routing protocols***

Reactive routing protocols maintain information for active routes only. The routes are determined and maintained for nodes that require to send data to a particular destination node. Reactive routing protocols are also known as on-demand routing protocols. TORA,AODV and DSR are the examples.

C. *Hybrid routing protocols*

Hybrid routing protocols are a new generation of protocol, which are both proactive and reactive in nature. These protocols are designed to increase scalability by allowing nodes with close proximity to work together to form some sort of a backbone to reduce the route discovery overheads. ZRP is the example.

4. TEMPORALLY ORDERED ROUTING ALGORITHM (TORA)

The Temporally Ordered Routing Algorithm (TORA) is an efficient routing algorithm. It is highly adaptive. This algorithm is based on the concept of link reversal [2].TORA is proposed for highly dynamic mobile, multi-hop wireless networks. It is a source-initiated on-demand routing protocol. It finds multiple routes from a source node to a destination node. The main feature of TORA is that the control messages are localized to a very small set of nodes near the occurrence of a topological change. To achieve this, the nodes maintain routing information about adjacent nodes.

This protocol has three basic functions: Route creation, Route maintenance, and Route erasure [8]. TORA has a unique feature of maintaining multiple routes to the destination so that topological changes do not require any reaction at all. The protocol reacts only when all routes to the destination are lost. In the case of network partitions, the protocol is able to detect the partition and all the invalid routes are erased.

Properties of Routing	proactive routing protocols	Reactive routing protocols	Hybrid routing protocols
Routing Structure	Flat and hierarchical	Flat	Hierarchical

Availability of Routes	Always available, if the nodes are reachable to the destination	Determined when needed	Depends upon the location of destination
Storage Requirement	high	low	Based on the size of each cluster
Traffic Control volume	High	Low	Low when compared to pro-active and Reactive Protocols.
Examples	DSDV,OLSR	TORA, AODV, DSR	ZRP

Table 1.0 Routing Properties

TORA Algorithm

If (failure of link)
Generate reference level
Else
If (all neighboring nodes are not at same reference level)
Propagate reference level
Else
If (reference bit ==0)
Reflect Reference Level
Else
If (Reference Level created by the user)
Clear Reference Level
Else
Generate Reference Level

5. LITERATURE REVIEW

Comparative Analysis of AODV, OLSR, TORA, DSR and DSDV Routing Protocols in Mobile Ad-Hoc Networks is done by Dilpreet Kaur and Naresh Kumar [2].They have analyzed the characteristics of ad hoc routing protocols Ad-hoc On Demand Distance Vector Routing (AODV), Optimized link State Routing (OLSR), Temporally Ordered Routing Algorithm (TORA), Dynamic Source Routing (DSR), Destination-Sequenced Distance-Vector Routing (DSDV) based on the performance metrics like packet delivery fraction, Average delay, Normalized Routing load, Throughput and Jitter under low mobility and low traffic network as well as under high mobility and high traffic network. The Results conclude that AODV has maximum throughput under low traffic and DSDV has maximum throughput under high traffic. OLSR, DSR and DSDV perform well as the network becomes dense in terms of Throughput than AODV and TORA. In dense networks, TORA performs well in terms of packet delivery fraction but at the same time, Normalized Routing load of TORA is maximum among all the protocols in both the networks.

A Performance Comparisons of Routing Protocols (DSR and TORA) for Security Issue in MANET is done by Rakesh Kumar Jha, SV Limkar and DU Dalal [6].It was concluded that theConcurrent routing of both DSR and TORA routing protocols inthesame network have been evaluated for security issue. Nodes are divided into two ways without proxy enabled and proxy disabled Node work station. TORA is better suited for both casesin without and with security purpose for 50 fixed node work stationenvironment. They state that proxy environment is suitable for TORA Routing because the network will maintain the same behavior after proxy enabled too but DSR routing is highly affected by proxy.

Performance evaluation of AODV, DSR, DSDV, and TORA Routing Protocols is done by Er. Saurabh Mittal and Pinki [8]. They have analyzedfor the different reactive and proactive ad-hoc routing protocols.Therealistic comparison of three routing protocols AODV, DSR, DSDV and TORA in MANETs (Mobile Adhoc Networks) has been discussed.They have tested the effect of speed, no. of packets transmitted, lost, bytes, bitrate and packet delay for Destination Sequence Distance Vector (DSDV) protocol, Dynamic Source Routing (DSR), Ad-hoc OnDemand Distance Vector (AODV) and Temporally Ordered Routing Algorithm. By results they conclude that TORA and DSR shows the better performances as compared to AODV and DSDV routing protocols.

Comprehensive Study of Proactive and Reactive Protocols in MANET is done by Prabhjot Kaur, Dr.Shaveta Rani and Dr.Paramjeet Singh [12]. They compared the four MANET protocols such as OLSR, AODV, DSDV, and TORA. The comparison is based upon the different parameters and performance metrics. AODV has better performance in networks with higher mobility and large number of nodes. AODV works well with the low number of nodes but OLSR works better for large number of nodes. From the simulation results, AODV shows average performance and better results than DSDV. The packets are dropping in DSDV. The received rate can very low or can very high. The performance of DSDV is worse than AODV and OLSR. TORA has low performance for all parameters throughput, delay and network load.

Routing in Vehicular Ad-hoc Networks: A Survey is done by Fan Li, Yu Wang [13].They discussed about the research challenge of routing in VANETs and survey of recent routing protocols and related mobility models for VANETs. VANETs pose many unique networking research challenges, and the design of an efficient routing protocol for VANETs is very crucial.

6. SIMULATION SCENARIO

NS2 is mainly used in MANET researches [3]. NS2 is developed as a collaborative environment. It is distributed freely and it is open source. Using NS2, TORA routing protocol is analyzed in VANET environment. In general, NS2 provides users with a way of specifying such network protocols and simulating their corresponding behaviors. Due to its flexibility and modular nature, NS2 has gained constant popularity in the networking research community since its birth in 1989. The NS project is now a part of the VINT project that develops tools for simulation results display, analysis and converters that convert network topologies generated by well-known generators to NS formats.

The emergence of vehicular networks has encouraged the design of a set of new applications and protocols specifically

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for these kinds of networks. The evaluation of those in outdoor experiments, by using large-scale networks to obtain significant results, is extremely difficult due to several issues concerning available resources, accurate performance analysis, and reproducible results. Indeed, it is neither easy nor cheap to have a high number of real vehicles and a real scenario for only practical purposes. It is also difficult to analyze applications and protocols performance in an inherently distributed and complex environment like VANETs.

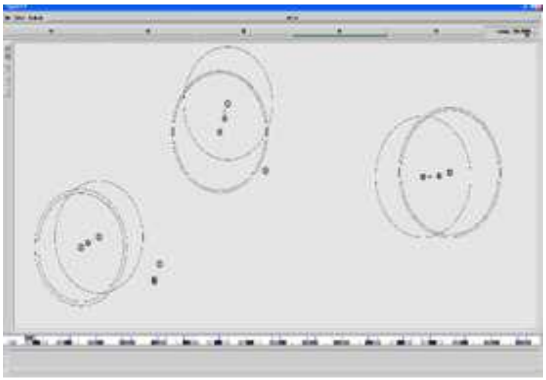

Fig. 1. Simulation Scenario

Simulation has become an indispensable tool because it makes possible to build a dedicated VANET for its evaluation. Simulators also gather statistical data about the network usage during the simulation that allows to measure the protocols performance. Moreover, it is possible to visualize the VANET in order to easily specify the scenarios for the protocol evaluation.

However, due to the complexity of the real world, a lot of the events related to the signal propagation that plays an important role in the performance of the outdoor experiments are missed in the simulations: passing by obstacles, reflection problems, signal interferences, etc. Thus, simulation also presents an important drawback: the fidelity of the generated results.

Parameter	Values
Number of nodes	30
Routing protocols	TORA
MAC layer	802.11
Mobility model	Random waypoint Model
Applications	CBR
Application packet size	512 bytes
Simulation Time	100 s
Maximum Speed	10 m/s

Table 2.0 Simulation Parameters

7. PERFORMANCE METRICS

Different performance metrics are used to check the performance of routing protocols in various network environments. In this paper, we have selected throughput, end-to-end delay and jitter for 30 vehicles (nodes) to check the performance of TORA routing protocol. The reason for the selection of these performance metrics is to check the performance of TORA routing protocol in highly mobile environment of VANET. Moreover, these performance metrics are used to check the effectiveness of VANET routing protocols i.e. how well the protocol deliver packets and how well the algorithm for a routing protocol performs in order to discover the route towards destination. The selected metrics for routing protocols evaluation are as follows:

i) **End to End delay:** It is the time taken for a packet to be transmitted across a network from source to destination

ii) **Throughput:** Throughput is the average rate of successful message delivery over a communication channel. In different words, it describes as the total number of received packets at the destination out of total transmitted packets. Throughput is calculated in data packets per second or bytes/sec. The simulation result shows that the overall received packets at destination in KB/Sec.

iii) **Jitter:** It describes standard deviation of packet delay between all nodes. It is define the mean deviation of the packets from source to destination for number of vehicles. Jitter is caused primarily by delays and congestion in the packet network.

8. RESULT AND ANALYSIS

In the first scenario, throughput of sending bits vs Minimal End 2 End delay are considered. End 2 End delay is the average time interval between the generation of packets in a source node and successfully delivery of it in a destination node. The performance would be better when it is low.

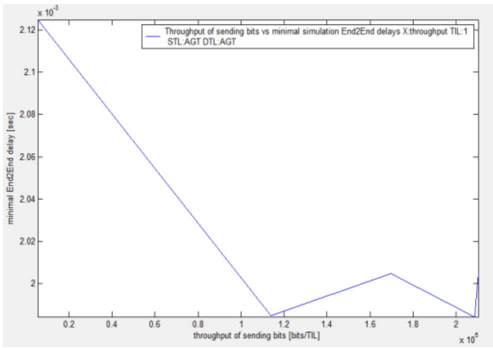

Fig. 2. Throughput of Sending bits vs Minimal End 2 End delay

Throughput vs Delay graph shows throughput (bits) on X axis and delay on Y axis. The average end to end delay increased in TORA as the number of nodes in the network were increased. Packet loss in TORA increased due to delay.

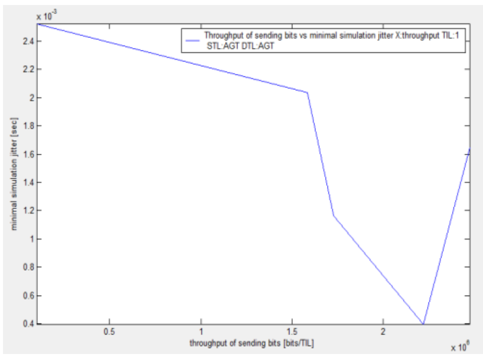

Fig. 3. Throughput of Sending bits vs Minimal Simulation Processing time

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Throughput measures how well the network can constantly provide data to the destination. Throughput vs Processing time graph shows throughput (bits) on X axis and processing time on Y axis.

Throughput and minimal processing times are calculated every time interval. Throughput of sending bits and processing times can be calculated at Current node or in the whole network (simulation processing time).

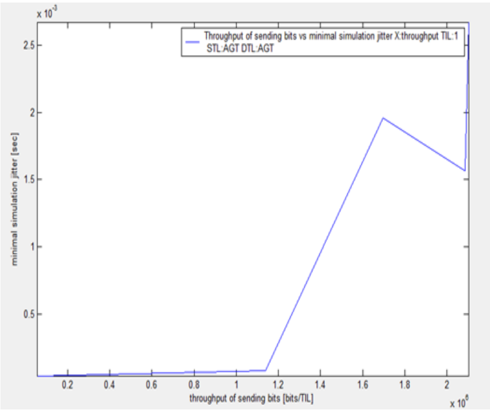

Fig. 4. Throughput of sending bits vs Minimal simulation jitter

Throughput vs Jitter graph shows Throughput on X axis and minimal simulation jitter on Y axis. Throughput is calculated in each time interval and then minimal is calculated from all the time intervals.For achieving better performance, throughput should be high.

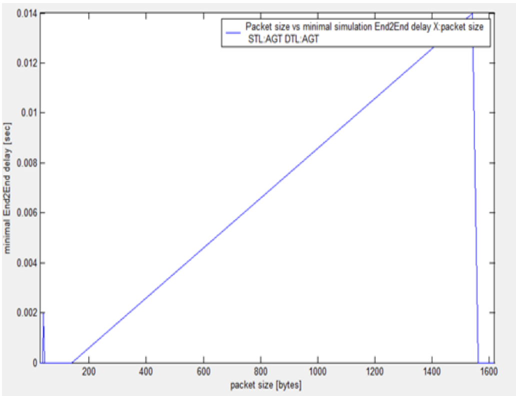

Fig. 5. Packet Size vs Minimal End to End delay

Packet size vs End to End delay graph shows Packet size on X axis and minimal End to End delay on Y axis.Graph delays of received packets are calculated in the same time intervals as throughput is calculated.

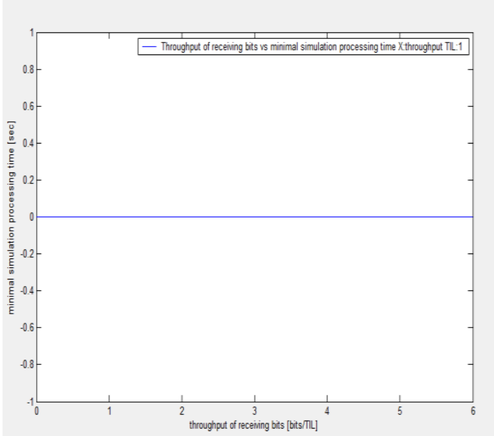

Fig. 6. Throughput of Receiving bits vs Minimal Simulation Processing time

Throughput measures how well the network can constantly provide data to the destination. Throughput vs Processing time graph shows throughput (bits) on X axis and processing time on Y axis.

Throughput and minimal processing times are calculated every time interval. Throughput of receiving bits and processing times can be calculated at Current node or in the whole network (simulation processing time).

9. CONCLUSION

In this paper, the performance of TORA is analyzed using simulation tool NS2. The protocol has been tested on NS2 simulator by using metrics - throughput, jitter, average end-to-end delay, processing time and packet size. TORA shows a better performance for large networks with low mobility rate. TORA is suitable for operation in large mobile networks having dense population of nodes. TORA supports multiple routes and multicasting.

This work can further be extended by performing simulation with different traffic scenarios and by comparing it with cluster based routing protocol for VANETs.

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AUTHOR PROFILES

Mrs.R.Jeevitha has completed her Master of Philosophy in Computer Science in Bharathiar University, Coimbatore, India. Her field of interests include Mobile Computing and Computer Networks. She has ten Publications in International Journals to her credit. She has also presented four papers in International Conference and five papers in National Conferences. Currently she is working as an Assistant Professor in the Department of Computer Applications in Karpagam Academy of Higher Education, Karpagam University, Coimbatore, India.

Mrs. K. Thilakavalli, She has completed her Bachelor of Physics degree in Bharathiar University in the year of 2006. She completed her Master of Computer Applications degree in Anna University in the year 2009. She completed her Master of Philosophy in PRIST University in the year of 2010. She has 6 Years 6 months experience in the field of Teaching. She published 10 International Journal papers, three International Conference papers, and two National Conference papers. Her research area of Interest is Image Processing, Computer Networks (Wireless & Wired), Mobile Computing, Data Mining. Currently she is working as an Assistant Professor in the Department of Computer Applications in Karpagam Academy of Higher Education, Karpagam University, Coimbatore, Tamilnadu, India.

Mr. D. Rajagopal, he has completed his Bachelor of Computer Science degree and completed his Master of Computer Applications degree in Periyar University in the year 2003 and 2006 respectively. He completed his Master of Philosophy in PRIST University in the year of 2012. He has 3 Years and 10 Months Experience in the field of Software Developing and 6 Years and 6 months Experience in the field of Teaching. He published 10 International Journal papers and a National Conference paper. He delivered more than 10 seminar & training programs for different Academic Institutions. His research area of Interest is Computer Networks (Wireless & Wired), Image Processing, Mobile Computing, Data Mining, Software Programming (OOPS). He is the life time member of MISTE, MIAENG. Currently I am working as an assistant professor in the department of computer science, Vivekanandha College of Arts and Sciences for women, Tiruchengode.