PERFORMANCE ANALYSIS OF ROUTING PROTOCOLS FOR 802.11P INCLUDING PROPAGATION MODELS

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ABSTRACT

Vehicular ad hoc network (VANET) is emerging as one of the challenging research area because of the heavy dependency of human being into vehicles which tends to develop an intelligent transport system. VANET is treated as an extension of mobile ad hoc network (MANET) due to its behavior and its working mode. VANET is emerging as a new powerful tool to provide safety and security to the human beings during the time of traveling from one place to another. Routing is one of the challenging tasks for both MANET and VANET due to the frequent change in the topology. In this paper, we are evaluating the adaptability of existing MANET routing protocols for VANET. In this research work, I am evaluating the performance of MANET routing protocols for VANET and assessing their adaptability for VANET. Also, the aim of this work is to analyze the impact of the propagation models on the MANET routing protocols in the vehicular environment. This will help to develop a new routing protocols or to have some improvement in IEEE 802.11p VANET infrastructure.

Keyword: - *VANET, Routing protocols, propagation models, DSDV, OLSR, AODV, 802.11p, WAVE*

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1. INTRODUCTION

1.1 VANET

The traffic related accidents are a key cause of death globally, and a topmost cause of death amongst those are in the age group of 15-29 years [1].
There are several types of infrastructure-less networks. One of them is ad-hoc networks. Ad-hoc networks are assembly of wireless nodes without any stationary infrastructure. MANET is one of the types of the ad-hoc networks. VANETs are categorized as application of MANET that has very high vehicular mobility and can be applicable in advancements of road safety and travel applications. VANET is relatively more dynamic in nature and ever-changing compared to MANET. This results in far more disconnected links between nodes. Another major difference is that MANET usually deals with various mobile nodes whereas in VANET we need to establish communication links between very mobile nodes (vehicles) and stationary nodes (infrastructure nodes). Unlike MANET, VANET involves some infrastructure. VANET node to node connectivity can be either V2V (Vehicle to Vehicle) or V2I (Vehicle to Infrastructure) or I2V (Infrastructure to Vehicle) [2]. RSU (Road-side Units) are usually connected to a backbone network such as the Internet [3].
Following are the characteristics of VANET [4]:

- VANET nodes can be classified into RSU (Road Side Units) and mobile units (vehicles)
- Movements of vehicular nodes are faster compared to mobile nodes in MANET
- Road topology affects movement of vehicular nodes
- Vehicles act as transceiver, thus sending and receiving data at the same time while forming a dynamic network
- Node density is highly variable. It would be very high during peak hours and low at night times.

1.2 Justifying the need to analyze impact of propagation models

Various studies have shown that there is significant difference in performance of routing protocols in both MANET and VANET environments. A routing protocol which performs better in MANETs may not perform with similar efficiency in VANET environments. Also, density of nodes, topology of network and environment plays the key role in the performance of wireless communication networks. Various studies have also proven that the selection of an appropriate propagation model play a key role in the selection of routing protocol since it can severely affect the performance of MANET infrastructure. Therefore analyzing the effects of propagation models in VANET becomes even more important as it is more dynamic compared to MANET environments and has various kinds of possibilities in different environments. Hence, a more thorough analysis is required to analyze the impact of propagation models on the performance of routing protocols in VANET environments [4].

2. ROUTING PROTOCOLS

Establishing strong routes, maintenance and reconstruction of routes in time are the main tasks of routing protocols. Routing protocols are the pillar of ad hoc networks. They generate complete routes between every couple of nodes from the topology information they are able to perceive. MANET routing is broadly categorized into three categories: Proactive, reactive and hybrid.

2.1 Proactive Routing Protocols

In proactive routing, the routers build and maintain updated routing information to all the nodes regardless of the necessity. For constructing routing information, intermittently they transmit control messages. Generally, proactive routing protocols are not reasonable to utilize bandwidth, as even if there is no data flow, the control messages are still broadcasted. One of the main advantages of proactive routing protocols is that nodes can fetch routing information easily. The problem with such type of routing is that there is too much overhead kept by the nodes for route protection and reformation is slow when there is a failure in a current link. DSDV, OLSR, Fisheye state routing (FSR) and Wireless Routing Protocol (WRP) are few examples of proactive routing protocols [4].

2.2 Reactive Routing Protocols

These protocols are the demand-oriented, which find the path whenever it needs. In such types of protocols, to establish a route there will be a route request (RREQ) and route reply messages sent by the source and destination node respectively. For RREQ, source node uses flooding in which it broadcasts a request message to all the connected nodes exist in its range. Nodes maintain only the active route until the destination node becomes inaccessible along every existing path from the source node. The protocols like ad-hoc on-demand distance vector Routing (AODV), DSR etc. exist in this category.

2.3 Hybrid Routing Protocols

A hybrid protocol uses the features of proactive and reactive routing protocols in a solitary protocol. The example of such routing protocol is ZRP which combines the proactive and reactive routing methodologies.

2.4 AODV (Ad-Hoc on Demand Distance Vector)

AODV uses broadcast mechanism for route detection. AODV depends on the dynamically established routing table entries at the numerous intermediate nodes [5]. To sustain the most recent route it uses the technique of destination sequence number used in DSDV; however each node maintain the sequence number counter individually in an cumulative order which will increase the efficiency of bandwidth by lessening the network load. Whenever a node needs to establish a communication, it floods an RREQ message in the network to construct a route. The entire process consists of two procedures: Path Discovery and Path Maintenance.

2.5 DSDV (Destination Sequence Distance Vector)

The DSDV protocol is based on the Distributed Bellman-Ford algorithm [6]. Messages are exchanged between source and destination through a single path, which is computed using the distance vector algorithm. To reduce the network overhead, two types of update packets are used: known as a ‘‘full dump’’ and ‘incremental’ packets. The full dump packet contains all the currently available updated routing information and the incremental packet contains only the new changed information since the last full dump message. Frequently, the incremental update packets are sent. [7] However, still DSDV have a large amount of routing overhead due to the periodic update. Therefore, the protocol will not scale in a large network like VANET, since a large portion of the network bandwidth will be used in the updating procedures.

2.6 OLSR (Optimized Link State Routing)

Optimized Link State Routing (OLSR) [8] is an optimization of pure link state protocol. In this protocol, all the link information of the neighboring nodes is flooded in the entire network. This protocol decreases the size of the control messages by using a method called multipoint relay. [9] In the multipoint relay, the size of control packets are reduced by dropping identical retransmission packets in the same region. Each control message has a sequence number of current information, therefore, it does not request an ordered delivery of packets. In OLSR, each node in the network broadcasts HELLO message after a predetermined interval of time which carries the link status information of neighbors of respective nodes. OLSR working can be categorized into four phases: sensing of neighbors, selection of multipoint relay, declaration of multipoint relay information and calculation of the routing table.

3. PROPAGATION MODELS

A radio propagation model, also known as the Radio Wave Propagation Model or the Radio Frequency Propagation Model, is an empirical mathematical formulation for the characterization of radio wave propagation as a function of frequency, distance and other conditions. A single model is usually developed to predict the behavior of propagation for all similar links under similar constraints. Created with the goal of formalizing the way radio waves are propagated from one place to another, such models typically predict the path loss along with a link or the effective coverage area of a transmitter.

3.1 Friis Propagation Model

The Friis propagation model assumes the ideal propagation condition that there is only one clear line-of-sight path between transmitter and receiver. [10] It is ideal for the places where there are little to none obstacles in between the transmitters and receivers. The Friis propagation model is effective only for propagation in free space within the far field region.

3.2 Two-Ray Ground Propagation Model

Two-Ray Ground propagation model considers both the direct path and a propagation path reflected from the ground, between a receiver and a transmitter. This mode is more accurate in prediction at long distances in comparison to the Friis propagation model, while in short distances this model does not give good results. The Two-Ray Ground propagation model does not give a good outcome for short distances, due to the fluctuation caused by a constructive and destructive combination of the two multipath rays. Instead, the Friis free-space propagation model is used for small distances.

3.3 ITU R 1411 Propagation Model

ITU R 1411 propagation model is developed for the planning of short-range outdoor radio communication systems and radio local area networks in the frequency range of 300 MHz to 100 GHz [11]. This propagation model covers the frequency of IEEE 802.11p. It gives the information on both line-of-sight and non-line-of-sight environments. This propagation model does not consider hilly areas as they are less typical in metropolitan areas. This propagation model is suitable for urban, suburban and rural areas. It supports the vehicular speeds up to 100 km/h. It can be employed indoor or outdoor and has supported range up to 1 km.

3.4 Nakagami Fading

Nakagami fading is very versatile as it can model a large variety of fading channel. Nakagami is a generic fading model. This propagation loss model implements the Nakagami fast fading model, which accounts for the variations in signal strength due to multipath fading. The model does not account for the path loss due to the distance travelled by the signal, hence for typical simulation usage, it is recommended to consider using it in combination with other models that take into account this aspect.

4. SIMULATION RESULTS

The network simulations are run on the ns3 network simulation tool's version 3.26 on the Linux Mint 18.2. The performance of various routing protocols has been evaluated. The purpose of comparing the performance of various routing protocols is to find the differences in terms of the performance in order to find the best suitable routing protocol in the vehicular environments.
The following table shows the simulation parameters used for the VANET network simulations.

Table-1 Simulation Parameters

Parameter	Value	
MAC	802.11p	
OFDM Data rate	6 Mbps	
Bandwidth	10 MHz	
Frequency	5.9 GHz	
Safety Message Size	200 byte	
Routing Protocols	AODV, DSDV, OLSR	
Propagation Models – with Nakagami Fading	Friis, ITU R 1411, Two-Ray Ground	
Vehicle density	20, 50, 100	
Vehicle Speed	20 m/s (72 km/h)	
Geographical Area	Coordinates	22.2994°N, 70.7856°E 22.2881°N, 70.8047°E
	Dimensions	1,257 m x 1,965 m
	Area	2.47 $kilometers^2$
Simulation Time	150 s	

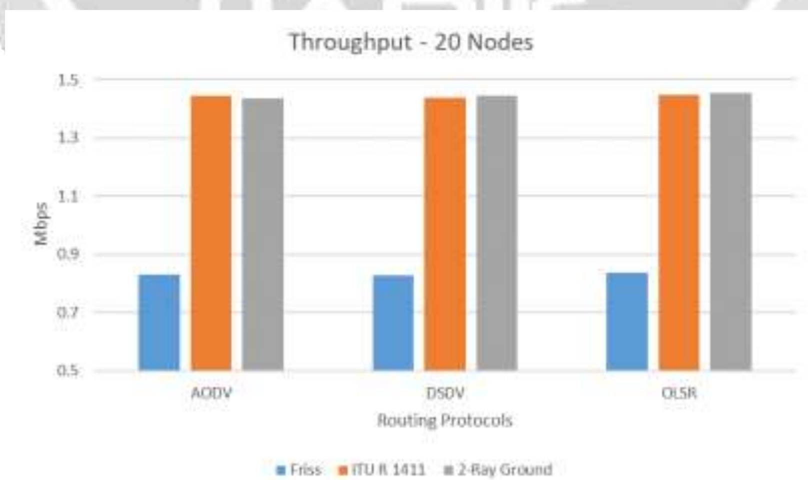

Chart-1 Throughput comparison under all propagation models for 20 nodes

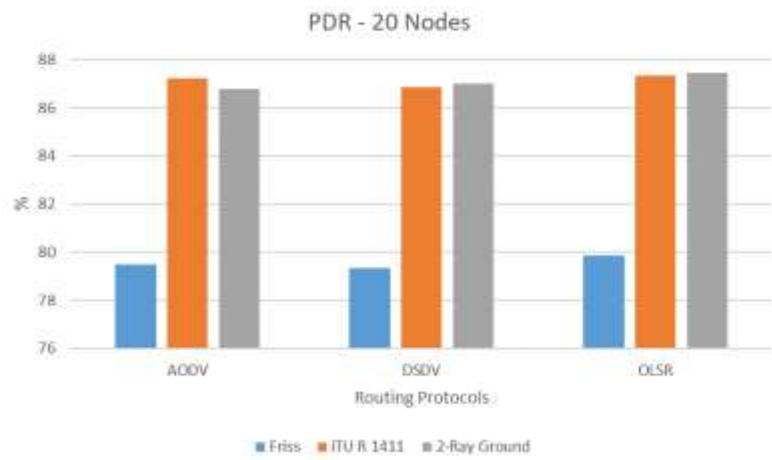

Chart-2 PDR Comparison under all propagation models for 20 nodes

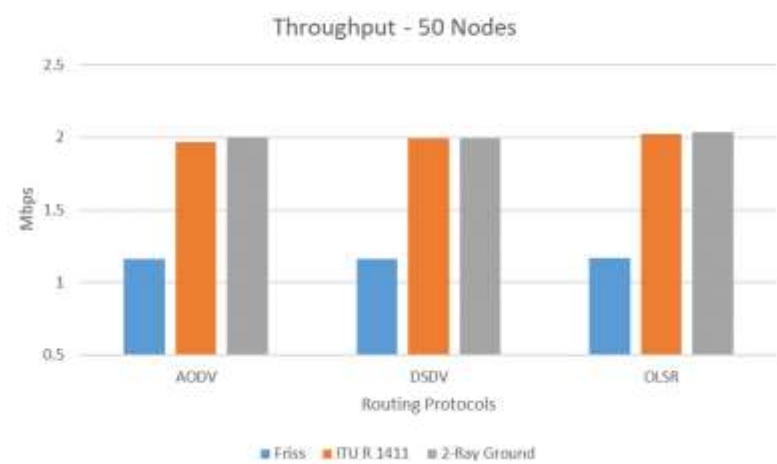

Chart-3 Throughput comparison under all propagation models for 50 nodes

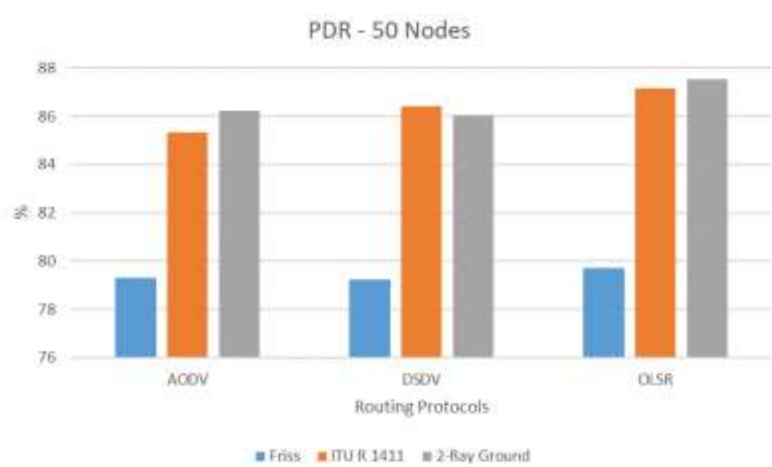

Chart-4 PDR Comparison under all propagation models for 50 nodes

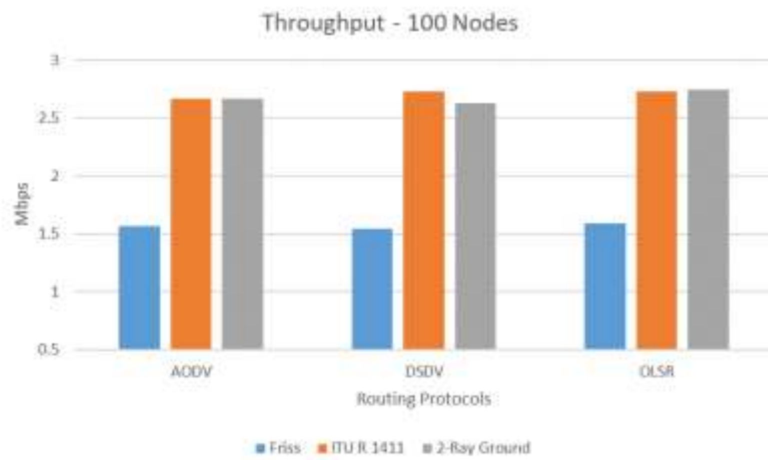

Chart-5 Throughput Comparison under all propagation models for 100 nodes

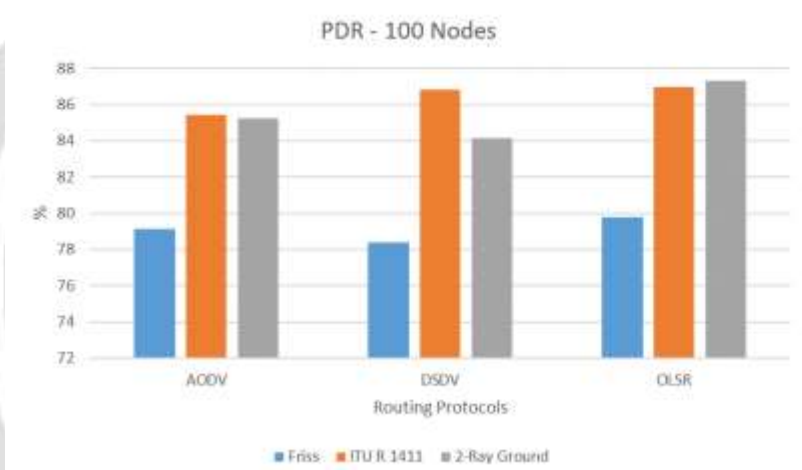

Chart-6 PDR Comparison under all propagation models for 100 nodes

The following table represents the values associated with colours.

Table-2 Data representation with colours

	Highest		2nd Highest		3rd Highest
	4th Highest		5th Highest		6th Highest

Table-3 Summary of obtained results for 20 nodes

Routing Protocol / Propagation Model	AODV		DSDV		OLSR	
	T	**PDR**	**T**	**PDR**	**T**	**PDR**
Friis						
ITU R 1411						
2-Ray Ground						

From the Table-3, it is evident that the OLSR routing protocol along with the Two-Ray Ground propagation model is the best choice in terms of both throughput and reliability. An alternative combination is to use the OLSR routing protocol under ITU R 1411 propagation model. Although the AODV routing protocol has less throughput it is more reliable under the ITU R 1411 propagation model when compared with the DSDV routing protocol under Two-Ray

Ground propagation model. Therefore, the AODV routing protocol under the ITU R 1411 propagation model can be the second alternative at lower node densities.

Table-4 Summary of obtained results for 50 nodes

Routing Protocol / Propagation Model	AODV		DSDV		OLSR	
	T	PDR	T	PDR	T	PDR
Friis						
ITU R 1411						
2-Ray Ground						

From the Table-4, it is apparent that the OLSR routing protocol along with the Two-Ray Ground propagation model is the best choice in terms of both throughput and reliability. As it is the case with the networks of 20 nodes, an alternative combination is to use the OLSR routing protocol under the ITU R 1411 propagation model. The second alternative is to use the DSDV routing protocol under the ITU R 1411 propagation model as it is more reliable compared to the AODV routing protocol under the Two-Ray Ground propagation model.

Table-5 Summary of obtained results for 100 nodes

Routing Protocol / Propagation Model	AODV		DSDV		OLSR	
	T	PDR	T	PDR	T	PDR
Friis						
ITU R 1411						
2-Ray Ground						

From the Table-5, it is apparent that the OLSR routing protocol along with the Two-Ray Ground propagation model is the best choice in terms of both throughput and reliability. As it is the case with networks of 20 and, 50 nodes, an alternative combination is to use the OLSR routing protocol under the ITU R 1411 propagation model. The second alternative is to use the DSDV routing protocol under the ITU R 1411 propagation model.

5. CONCLUSION

The OLSR routing protocol under the Two-Ray Ground propagation model provides the best performance in terms of throughput and reliability under all node densities. Therefore, this combination of routing protocol-propagation model can be used under urban scenarios with various traffic situations. In similar conditions, the second best combination of a routing protocol and a propagation model is to use OLSR under the ITU R 1411 propagation model. For areas with low traffic, AODV with the ITU R 1411 propagation model can also be used as an alternative. Whereas for areas with higher traffic the alternative is to use DSDV with the ITU R 1411 propagation model.

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