Performance Evaluation of AODV, DSR, DYMO & ZRP in Cost 231 Walfisch-Ikegami Path Loss Propagation Model

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Abstract: *A Mobile Ad hoc NETwork is a kind of wireless ad-hoc network, and is a self configuring network of mobile routers connected by wireless links. Mobile Ad-Hoc Network (MANET) is a wireless network without infrastructure. Self configurability and easy deployment feature of the MANET resulted in numerous applications in this modern era. Efficient routing protocols will make MANETs reliable. Various research communities are working in field of MANET and trying to adopt the protocols and technology in other applications as well. In this work, we present investigations on the behavior of various routing protocol of MANET with a Cost 231 Walfisch-Ikegami Propagation Model. We evaluate* *the performance of four different ad-hoc routing protocols on four performance metrics such as Average Jitter, Average End-to-End Delay, Throughput, and Packet Delivery Fraction with varying Pause Time. From the simulation results it is concluded that DSR is better in transmission of packets per unit time and maximum number of packets reached their destination successfully with some delays, i.e. PDF & Throughput is more and Average jitter & end-to-end delay is less. Whereas AODV & ZRP having almost same values in all of the performance metrics, they transmit packets with very less delay but transmits less packets to their destination as compare to DSR.*

Keywords: *Ad hoc Network, AODV, DSR, DYMO, ZRP, Cost 231 Walfisch -Ikegami propagation model.*

Introduction

A "mobile ad hoc network" (MANET) [1] is an autonomous system of mobile routers (and associated hosts) connected by wireless links--the union of which form an arbitrary graph. The routers are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. Such a network may operate in a standalone fashion, or may be connected to the larger Internet.

For MANET, a number of prominent routing protocols have been proposed in the literature, to name a few, AODV (Ad hoc On-demand Distance Vector), DSR (Dynamic Source Routing), DYMO (Dynamic MANET On-demand Routing Protocol) and ZRP (Zone Routing Protocol). All the above protocols are operating only in the Network layer. In data link layer, number of propagation model is available such as two ray's propagation model, free space propagation model and Cost 231 Walfisch-Ikegami propagation model. In this work, we present investigations on the behavior of various networks routing protocol with Cost 231 WI propagation model. We do not present an optimized routing protocol. We present a study on the performance of four different ad hoc routing protocols using Cost 231 WI propagation model.

The rest of this paper is organized as follows. Section II briefly describes the Routing Protocols for ad-hoc network. In Section III, overview of propagation model is explained. In Section IV, the simulation Experiment and Parameter Metrics are shown and in Section V is simulation results and last Section VI concludes this paper.

Protocol Description

The routing of traffic between nodes is performed by a MANET routing protocol. MANET routing protocols can be divided into three categories. In table driven/ proactive routing protocols, nodes periodically exchange routing information and attempt to keep up-to-date routing information. In on-demand/reactive routing protocols, nodes only try to find a route to a destination when it is actually needed for communication and hybrid protocols. The hybrid approach combines properties of both periodic and reactive routing protocols.

All the above protocols have two main mechanisms of "Route Discovery" and "Route Maintenance", working together to allow nodes to discover and maintain routes to arbitrary destinations in the ad hoc network.

Ad Hoc On-Demand Distance Vector Routing (AODV)

AODV [2] shares DSR's on-demand characteristics in that it also discovers routes on an as needed basis via a similar route discovery process. However, AODV adopts a very different mechanism to maintain routing information. It uses traditional routing tables, one entry per destination. This is in contrast to DSR, which can maintain multiple route cache entries for each destination. Without source routing, AODV relies on routing table entries to propagate an RREP back to the source and, subsequently, to route data packets to the destination. AODV uses sequence numbers maintained at each destination to determine freshness of routing information and to prevent routing loops. All routing packets carry these sequence numbers.

An important feature of AODV is the maintenance of timer-based states in each node, regarding utilization of individual routing table entries. A routing table entry is expired if not used recently. A set of predecessor nodes is maintained for each routing table entry, indicating the set of neighboring nodes which use that entry to route data packets. These nodes are notified with RERR packets when the next-hop link breaks. Each predecessor node, in turn, forwards the RERR to its own set of predecessors, thus effectively erasing all routes using the broken link. In contrast to DSR, RERR packets in AODV are intended to inform all sources using a link when a failure occurs. Route error propagation in AODV can be visualized conceptually as a tree whose root is the node at the point of failure and all sources using the failed link as the leaves.

Dynamic Source Routing (DSR)

The key distinguishing feature of DSR is the use of source routing [3, 4]. That is, the sender knows the complete hop-by-hop route to the destination. These routes are stored in a route cache. The data packets carry the source route in the packet header. When a node in the ad hoc network attempts to send a data packet to a destination for which it does not already know the route, it uses a route discovery process to dynamically determine such a route. Route discovery works by flooding the network with route request (RREQ) packets. Each node receiving an RREQ rebroadcasts it, unless it is the destination or it has a route to the destination in its route cache. Such a node replies to the RREQ with a route reply (RREP) packet that is routed back to the original source. RREQ and RREP packets are also source routed. The RREQ builds up the path traversed across the network. The RREP routes itself back to the source by traversing this path backward. The route carried back by the RREP packet is cached at the source for future use.

If any link on a source route is broken, the source node is notified using a route error (RERR) packet. The source removes any route using this link from its cache. A new route discovery process must be initiated by the source if this route is still needed. DSR makes very aggressive use of source routing and route caching. No special mechanism to detect routing loops is needed. Also, any forwarding node caches the source route in a packet it forwards for possible future use.

Dynamic MANET On-demand (DYMO)

The Dynamic MANET On-demand (DYMO) [5] routing protocol enables reactive, multihop unicastrouting between participating DYMO routers. The basic operations of the DYMO protocol are route discovery and route maintenance. During route discovery, the originator's DYMO router initiates dissemination of a Route Request (RREQ) throughout the network to find a route to the target's DYMO router. During this hop-by-hop dissemination process, each intermediate DYMO router records a route tothe originator. When the target's DYMO router receives the RREQ, it responds with a Route Reply (RREP) sent hop-by-hop toward the originator. Each intermediate DYMO router that receives the RREP creates a route to the target, and then the RREP is unicast hop-by-hop toward the originator. When the originator’s DYMO router receives the RREP, routes have then been established between the originating DYMO router and the target DYMO router in both directions. Route maintenance consists of two operations. In order to preserve routes in use, DYMO routers extend route lifetimes upon successfully forwarding a packet. In order to react to changes in the network topology, DYMO routers monitor links over which traffic is flowing. When a data packet is received for forwarding and a route for the destination is not known or the route is broken, then the DYMO router of source of the packet is notified. A Route Error (RERR) is sent toward the packet source to indicate the current route to a particular destination is invalid or missing. When the source's DYMO router receives the RERR, it deletes the route. If the source's DYMO router later receives a packet for forwarding to the same destination, it will need to perform route discovery again for that destination. DYMO uses sequence numbers to ensure loop freedom. Sequence numbers enable DYMO routers to determine the order of DYMO route discovery messages, thereby avoiding use of stale routing information.

Hybrid Routing Protocol (ZRP)

ZRP is a hybrid routing protocol, which effectively combines the best features of both periodic and reactive routing protocols. An intra-zone routing protocol (IARP) is used in the zone where a particular node employs proactive routing. The reactive routing used beyond this zone is referred to as inter-zone routing protocol (IERP). Each node maintains the information about routes to all nodes within its routing zone by exchanging periodic route update packets. Hence the larger the routing zone, the higher the update control traffic. The IERP is responsible for finding paths to the nodes, which are not within the routing zone. When the node has data packets for a particular destination, it checks its routing table for a route. If the destination lies within the zone, a route will exist in the route table. Otherwise, if the destination is not within the zone, a search to find a route to that destination is needed [6].

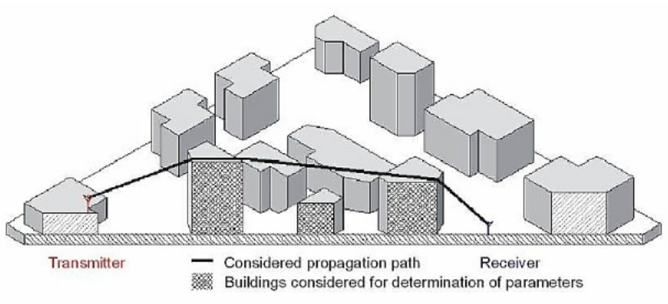
Propagation Model

A propagation model is a set of mathematical expressions, diagrams, and algorithms used to represent the radio characteristics of a given environment [7].

Cost 231 (Walfisch and Ikegami) Model

This empirical model is a combination of the models from J. Walfisch and F. Ikegami. It was developed by the COST 231 project. It is now called Empirical COST-Walfisch-Ikegami Model [8]. The frequency ranges from 900MHz to 1800 MHz.

The model considers only the buildings in the vertical plane between the transmitter and the receiver. The accuracy of this empirical model is quite high because in urban environments especially the propagation over the rooftops (multiple diffractions) is the most dominant part. Only wave guiding effects due to multiple reflections are not considered.



Path Loss,

$$L_{50}(dB) = L_f + L_{rts} + L_{msd}$$

where

L_f = free-space loss

L_{rts} = rooftop-to-street diffraction and scatter loss

L_{msd} = multi screen loss

Free space loss is given as

$$L_f = 32.4 + 20\ log d + 20 log\ f_c dB$$

The rooftop-to-street diffraction and scatter loss is given as:

$$L_{rts} = -16.9 - 10\log\left(\frac{w}{m}\right) + 10\log\left(\frac{f}{MHz}\right) +$$

$$20\log\left(\frac{\Delta h_{mobile}}{m}\right) + L_{Ori}$$

$$L_{Ori} = \begin{cases} -10 + 0.354\frac{\varphi}{deg} & for\ \ 0^o \le \varphi < 35^0 \\ 2.5 + 0.075\left(\frac{\varphi}{deg} - 35\right) for\ \ 35^0 \le \varphi < 55^0 \\ 4.0 + 0.114\left(\frac{\varphi}{deg} - 55\right) for\ \ 55^0 \le \varphi < 90^0 \end{cases}$$

With *w* = width of the roads

Where L_{ori} = Orientation Loss

φ= incident angle relative to the street

The multi screen loss is given as:

$L_{msd} = L_{bsh} + k_a + k_d \log_d + k_f \log f_c - 9 \log b$

This model is restricted to the following range of parameter: frequency range of this model is 900 to 1800 MHz and the base station height is 4 to 50 m and mobile station height is 1 to 3 m, and distance between base station and mobile station d is 0.02 to 5km.

Simulation Parameters

Parameter values for Simulation

Maximum Simulation time	**200 Seconds**
Physical Terrain-Dimensions (meters)	500 X 500
Number of nodes	50
Mobility Model	Random Way Point
Routing Protocol	AODV, DSR, DYMO, ZRP
Propagation model	Cost 231 Walficsh Ikagami Model
Channel Frequency	1.5 GHz
Shadowing Model	Constant
MAC layer Protocol	IEEE 802.11
Traffic type	Constant Bit Rate
Node Placement	Random
Maximum Speed	10mps
Seed	1
Pause Time	10,20,30,40,50,100 Seconds

Simulation Model

We use a simulation model based on QualNet 5.0 [9] in our evaluation. QualNet is a discrete event simulator developed by Scalable Networks. It is extremely scalable, accommodating high fidelity models of networks of 10’s of thousands of nodes. QualNet makes good use of computational resources and models large-scale networks with heavy traffic and mobility, in reasonable simulation times.

Performance Metrics

Packet delivery fraction is the ratio of the number of data packets successfully delivered to the destination to those generated by CBR sources.

Packet delivery fraction = (Received packets/Sent packets)*100.

Throughput is the measure of the number of packets successfully transmitted to their final destination per unit time. It is the ratio between the numbers of sent packets vs. received packets.

Average End to End Delay signifies the average time taken by packets to reach one end to another end (Source to Destination).

Average Jitter Effect signifies the Packets from the source will reach the destination with different delays. A packet's delay varies with its position in the queues of the routers along the path between source and destination and this position can vary unpredictably.

Result & Analysis

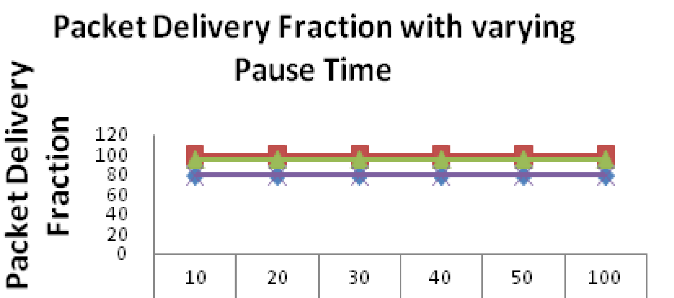
Fig. 1 shows the PDF with varying Pause time, DSR perform better among all of them i.e. it transmits maximum number of packets successfully to its destination. From the graph it seen that PDF of AODV & ZRP is same at all the Pause Times.

Here from the Fig. 2, Average Jitter of AODV & ZRP is very less and average jitter of DSR is comparatively more. Hence delays are more in DSR whereas in AODV & ZRP have very less delay.

In Fig. 3, throughput of DSR is more means number of packets transmittes per unit time is more in DSR in comaprison with other routing protocols, and AODV & ZRP having almost same values.

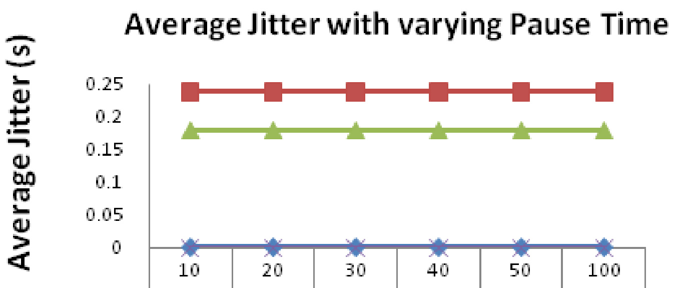
Fig. 4 Average End-to-End delay with varying Pause Time, here also

DSR having more delays comparatively with others, AODV & ZRP having almost negligible delay, i.e. average time taken by packets is less in AODV & ZRP.



	10	20	30	40	50	100
AODV	79.166	79.166	79.166	79.166	79.166	79.166
DSR	100	100	100	100	100	100
DYMO	95.833	95.833	95.833	95.833	95.833	95.833
ZRP	79.166	79.166	79.166	79.166	79.166	79.166

Figure 1. Packet Delivery Fraction with varying Pause Time



	10	20	30	40	50	100
AODV	0.00209	0.00209	0.00209	0.00209	0.00209	0.00209
DSR	0.23809	0.23809	0.23809	0.23809	0.23809	0.23809
DYMO	0.17954	0.17954	0.17954	0.17954	0.17954	0.17954
ZRP	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044

Figure 2. Average Jitter with varying Pause Time

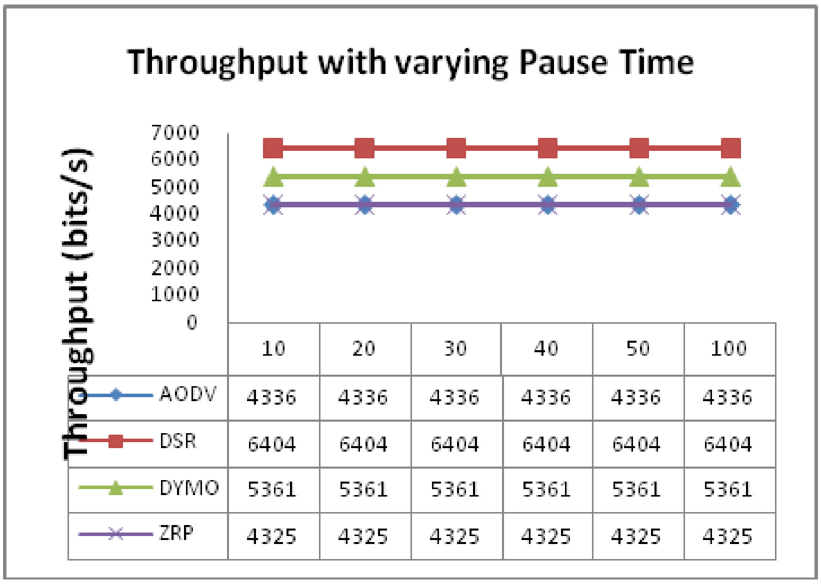


Figure 3. Throughput with varying Pause Time

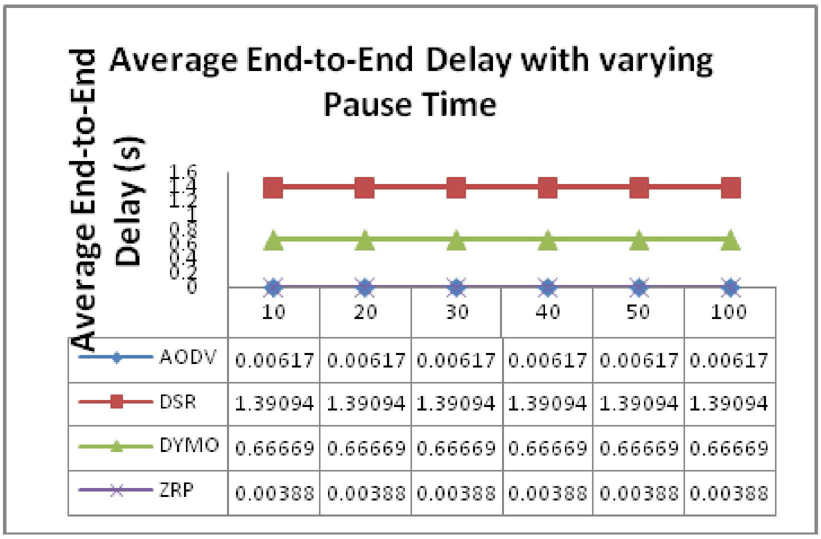


Figure 4. Average End-to-End Delay with varying Pause Time

Conclusions

In the conclusion it seen that in the Cost 231 Walfisch-Ikegami Propagation Model, DSR perform better among all of them as its Packet delivery fraction & Throughput is more but its packet takes little more time in reaching their final destination. DSR is better in transmission of packets per unit time and maximum number of packets reached their destination successfully with some delays.Whereas AODV & ZRP having almost same values in all of the performance metrics, they transmit packets with very less delay but transmits less packets to their destination as compare to DSR.

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