International Journal of Computer and Information Technology (ISSN: 2279 – 0764)
Volume 03 – Issue 06, November 2014

A Study on MANET Routing Protocol Performance with Node Mobility

Tulga Jargalsaikhan
Dept. of Computer Science and Engineering
Seoul National University of Science and Technology
Seoul, Korea

Kilhung Lee
Dept. of Computer Science and Engineering
Seoul National University of Science and Technology
Seoul, Korea
Email: khlee {at} seoultech.ac.kr

Abstract—**This study carried out on the behavioral aspect of two different MANET reactive routing protocols. AODV and DSR using network simulator ns-2 by varying the speed of node's mobility using constant bit rates. In a real world scenario, the nodes mobility speed frequently changed. In this paper assumed different speed. After all the analyses AODV performance is better than DSR in Throughput, Packet Delivery Ratio and End-to-end delay, especially when speed is high and many nodes. This would be a help for the people conducting research on real world problems in MANET Routing and other solutions.**

Keywords- MANET routing; AODV and DSR; node mobility; ns-2 performance evaluation

I. Introduction

A MANET (Mobile Ad-hoc Networks) consists of a number of mobile devices that come together to form a network as needed, without any support from any existing Internet infrastructure or any other kind of fixed stations [1]. Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. Depending upon the nature of application, appropriate routing protocol is implemented. Proactive and reactive protocols are the two classes of MANET routing protocols and each constitute a set of protocols as described below [2-4]. In this paper AODV (Ad Hoc On-Demand Distance Vector) [5] and DSR (Dynamic Source Routing Protocol) [6] are considered for evaluation using varying the speed in MANET. There are many papers that consider the performance of the ad-hoc routing protocols including DSDV (Destination-Sequenced Distance Vector) and OLSR (Optimized Link State Routing) [7-10].

Mobile ad hoc network nodes are furnished with wireless transmitters and receivers using antennas, which may be highly directional (point-to-point), omnidirectional (broadcast), probably steerable, or some combination. At a given point in time, depending on positions of nodes, their transmitter and receiver coverage patterns, communication power levels and co-channel interference levels, a wireless connectivity in the form of a random, multi-hop graph or "ad hoc" network exists among the nodes. This ad hoc topology may modify with time as the nodes move or adjust their transmission and reception parameters.

It is easy to imagine a number of applications where this type of properties would bring benefits. One interesting research area is inter vehicle communications. It is one area where the ad hoc networks could really change the way we communicate covering personal vehicles as well as professional mobile communications needs. Also, it is area where no conventional solutions would do because of the high level of mobility. When considering demanding surroundings, say mines for example, the neither would the base station approach work but we must be able to accomplish routing via nodes that are part of the network.

II. MANET Routing and Mobility Modes

A. *Dynamic Source Routing (DSR))*

The key distinguishing feature of DSR is the use of source routing [11]. 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 back to the source by traversing the path backwards. 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.

B. Ad Hoc On-Demand Distance Vector Routing (AODV)

AODV 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 [12]. 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.

C. AODV vs DSR

Dynamic Source Routing is commonly compared with AODV. Even though DSR is a multi-hop protocol and reactive protocol, route discovery mechanism is different. The most prominent difference is that DSR uses the source routing in which each packet contains the route to the destination in its own header. Therefore, intermediate nodes do not need to maintain up-to-date routing information in order to forward data packets. Another unique feature of DSR is packet salvaging. When an intermediate node detects the broken link to the next hop, the node begins to find an alternative route instead of discarding the data packet. In our experiments in NS2, we found that the packet salvaging causes the extension of end-to-end delay.

TABLE I. COMPARISON OF DSR AND AODV

Parameters	DSR	AODV
Routing Type	Source Routing	Distance Vector
Loop Freedom	Yes	Yes
Multiple Routers	Multiple routes not there	There are multiple routes
Destination Update Procedure	Source	Source
Router Stored	In Route cache	In routing table

D. Mobility Model

Nowadays, there are many network simulators that can simulate the MANET. In this section we will introduce the most commonly used simulators. We will compare their advantages and disadvantages and choose one to as platform to implement reactive/proactive protocol and conduct simulations in this thesis. Ns-2 [13] is a discrete event simulator targeted at networking research. It provides substantial support for simulation of TCP, routing and multicast protocols over wired and wireless networks. It consists of two simulation tools. The network simulator 2 (ns-2) contains all commonly used IP protocols. The network animator (NAM) is use to visualize the simulations. NS-2 fully simulates a layered network from the physical radio transmission channel to high-level applications.

To evaluate the performance of a protocol for an ad-hoc network, it is necessary to test the protocol under realistic conditions, especially including the movement of the mobile nodes. Surveys of different mobility models have been done [14]. This includes the Random Waypoint Mobility Model that is used in our work.

- Random Walk Mobility model [15]: This model is based on random directions and speeds. By randomly choosing a direction between 0 and 2 and a speed between 0 and Vmax, the mobile node moves from its current position. A recalculation of speed and direction occurs after a given time or a given distance walked. The random walk mobility model is memory less. Future directions and speeds are independent of the past speeds and directions. This can cause unrealistic movement such as sharp turns or sudden stops. If the specified time or distance is short, the nodes are only walking on a very restricted area on the simulation area.

- Random Waypoint Mobility model [16]: This model is very widely used in simulation studies of MANET. As described in the performance measures in mobile ad-hoc networks are affected by the mobility model used. One of the most important parameters in mobile ad hoc simulations is the nodal speed. The users want to adjust the average speed to be stabilized around a certain value and not to change over time. A mobile node begins the simulation by waiting a specified pause-time. After this time it selects a random destination in the area and a random speed distributed uniformly between 0 m/s and Vmax. After reaching its destination point, the mobile node waits again pause-time seconds before choosing a new way point and speed. The mobile nodes are initially distributed over the simulation area. This distribution is not representative to the final distribution caused by node movements. To ensure a random initial configuration for each simulation, it is necessary to discard a certain simulation time and to start registering simulation results after that time. They also want to be able to compare the performance of the mobile ad-hoc routing protocols under different nodal speeds. For the Random Waypoint Mobility Model common expectation is that the average is about half of the maximum, because the speeds in a Random Waypoint Model are chosen uniformly between 0 m/s and Vmax. But is this the average speed really reached in simulations? Not at all, the studies in show that the average speed is decreasing over time and will approach 0. This could lead to wrong simulation results. This phenomenon can be intuitively explained as follows. In the Random Waypoint Mobility Model a node selects its destination and its speed. The node keeps moving until it reaches its destination at that speed. If it selects a far destination and a low speed around 0 m/s, it travels for a long time with low speed. If it selects a speed near Vmax the time traveling with this high speed will be short. After a certain time the node has traveled much more time at low speed than at high speed. The average speed will approach 0 m/s. The suggestion in to prevent this problem is choosing, e.g. 1 m/s instead of 0 m/s as Vmin. With this approach the average speed stabilizes after a certain time at a value below 1/2*Vmax.

- Random Direction Mobility Model [17]: To reduce density waves in the average number of neighbors by the Random Direction Mobility Model was created. Density waves are the clustering of nodes in one part of the simulation area. For the Random Waypoint Mobility Model the probability of choosing a location near the center or a waypoint which requires traveling through the center of the area is high. The Random Direction Mobility Model was invented to prevent this behavior and to promote a semi-constant number of neighbors. The mobile node selects a direction and travels to the border of the simulation area. If the boundary is reached, the node pauses for a specific time and then chooses a new direction and the process goes on. Because of pausing on the border of the area, the hop count for this mobility model is much higher than for most other mobility models. A detailed simulation model based on ns-2 is used in the evaluation. In a recent paper the Monarch research group at Carnegie-Mellon University developed support for simulating multi-hop wireless networks complete with physical, data link, and medium access control (MAC) layer models on ns-2. The Distributed Coordination Function (DCF) of IEEE 802.11 for wireless LANs is used as the MAC layer protocol. An unslotted carrier sense multiple access (CSMA) technique with collision avoidance (CSMA/CA) is used to transmit the data packets. The radio model uses characteristics similar to a commercial radio interface, Lucent's WaveLAN [18]. WaveLAN is modeled as a shared-media radio with a nominal bit rate of 2 Mb/s and a nominal radio range of 250 m. The protocols maintain a send buffer of 64 packets. It contains all data packets waiting for a route, such as packets for which route discovery has started, but no reply has arrived yet. To prevent buffering of packets indefinitely, packets are dropped if they wait in the send buffer for more than 30s. All packets (both data and routing) sent by the routing layer are queued at the interface queue until the MAC layer can transmit them. The interface queue has a maximum size of 50 packets and is maintained as a priority queue with two priorities each served in FIFO order. Routing packets get higher priority than data packets.

III. Simulation and Results

A. Simulation Environments

The protocols are evaluated for throughput, packet delivery ratio and average end-to-end delay. These are the three main to get my final result:

- Throughput: Additional metrics can be used to measure the throughput of the protocol. One can use them to measure the portion of the available bandwidth that is used by the protocol for route discovery and maintenance.
- Packet Delivery Ratio: This is the number of packets sent from the source to the number of received at the destination.
- End-to-end Delay: This is the average time delay for data packets from the source node to the destination node.

All the tables and figures of average result of throughput, packet delivery ratio and end-to-end delay will be on next pages. We used ns-2 version 2.35 for my result. We set the different speed limit to low, medium, high, highest (1, 5, 10, 20). Also, each speed runs with 25, 36, 49, 64, 100 nodes. All the simulation environment parameters are shown in Table II.

TABLE II. Simulation Environments fot the Comparison of DSR and AODV

Antenna	Phy OMNI antenna
Propagation Model	SHADO
Mac	802.11 with 11mbps
Queue Length	50
Node Density	4096/ (km*km)

B. Simulation Results

In this table III used 25 nodes, the average result of 25 runs, the maximum speed set to 1. As you can see, there are no big differences between throughput, packet delivery ratio and end-to-end delay of DSR and AODV. AODV is slightly better than DSR. In few nodes and low speed, they both runs well.

TABLE III. Comparison of DSR and AODV at Nodes 25 and Speed of 1

Metrics	**DSR**	**AODV**
	Number of nodes 25	

Number of Runs	25	25
Maximum Speed	1	1
Throughput (kbps)	572.06	587.2
Packet Delivery Ratio (%)	96.5287	98.9472
End-to-end Delay (ms)	16.1242	11.3721

TABLE IV. COMPARISON OF DSR AND AODV AT NODES 36 AND SPEED OF 1

Metrics	**DSR**	**AODV**
	Number of nodes 36	
Number of Runs	25	25
Maximum Speed	1	1
Throughput (kbps)	441.12	459.81
Packet Delivery Ratio (%)	97.4396	98.965
End-to-end Delay (ms)	82.0879	23.386

TABLE V. COMPARISON OF DSR AND AODV AT NODES 49 AND SPEED OF 1

Metrics	**DSR**	**AODV**
	Number of nodes 49	
Number of Runs	25	25
Maximum Speed	1	1
Throughput (kbps)	365.1	353.56
Packet Delivery Ratio (%)	92.9134	93.2364
End-to-end Delay (ms)	187.583	119.035

TABLE VI. COMPARISON OF DSR AND AODV AT NODES 64 AND SPEED OF 1

Metrics	**DSR**	**AODV**
	Number of nodes 64	
Number of Runs	25	25
Maximum Speed	1	1
Throughput (kbps)	306.25	313
Packet Delivery Ratio (%)	89.2057	92.0797
End-to-end Delay (ms)	212.791	161.155

TABLE VII. COMPARISON OF DSR AND AODV AT NODES 100 AND SPEED OF 1

Metrics	**DSR**	**AODV**
	Number of nodes 100	
Number of Runs	25	25
Maximum Speed	1	1
Throughput (kbps)	193.32	220.97
Packet Delivery Ratio (%)	76.8497	85.0578
End-to-end Delay (ms)	380.751	280.628

In table IV, we add the nodes up to 36, the average result of 25 runs, came out with no difference between throughput and packet delivery comparison, when the maximum speed set to 1. But the only difference was end-to-end delay, DSR's result worse than AODV. When the nodes get higher, the end-to-end delay result of DSR's much higher than AODV. Table V shows the clear average results of 49 nodes. Here are little differences between throughput and packet delivery comparison after 25 runs, in maximum speed of 1. AODV outperforms DSR in end-to-end delay. Table VII shows the average result of 64 nodes after 25 runs, DSR performed worse than AODV. DSR's end-to-end delay not going well like AODV.

Table III to VII compares DSR and AODV throughput, packet delivery ratio and end-to-end delay in 25, 36, 49, 64 and 100 nodes, maximum speed set to 1. After all this runs AODV result was better than DSR result, even in few nodes and lowest speed. AODV performs much better in many nodes.

Some results in graph at maximum speed of the node is 1 and the speed of the node is varying from 25 to 100 is shown in Figure 1 to Figure 3. When the maximum speed set to 1m/s, the actual speed is random between 0 to 1m/s and the average speed 0.5m/s. The speed and direction is changes every 1 second. All other graphs at other simulation case show similar characteristics.

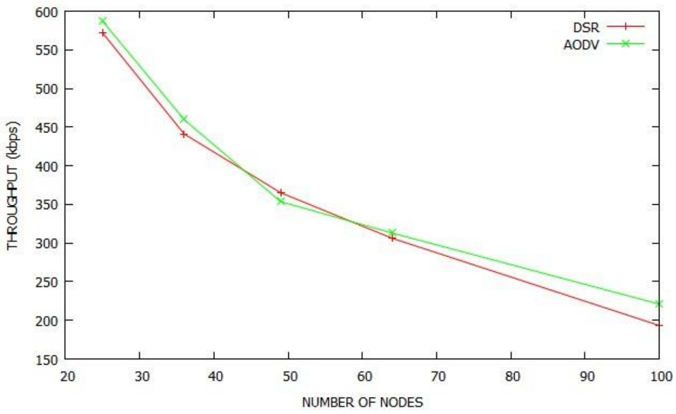

Figure 1. Average Throughput Graphic for maximum speed of 1 and the node number is varying from 25 to 100

It is defined as the total number of packets delivered over the total simulation time. The throughput comparison shows that the two algorithms performance margins are very close under traffic load of 25, 36, 49 and 64 nodes in MANET scenario and have large margins when number of nodes increases to 100. Mathematically, it can be defined as: Throughput=N/1000. Where N is the number of bits received successfully by all destinations. Figure 1 shows the clear result of Average Throughput. AODV performs best in terms of Average Throughput. The performance of DSR is good only for less no. of nodes. AODV performs better for large number of nodes.

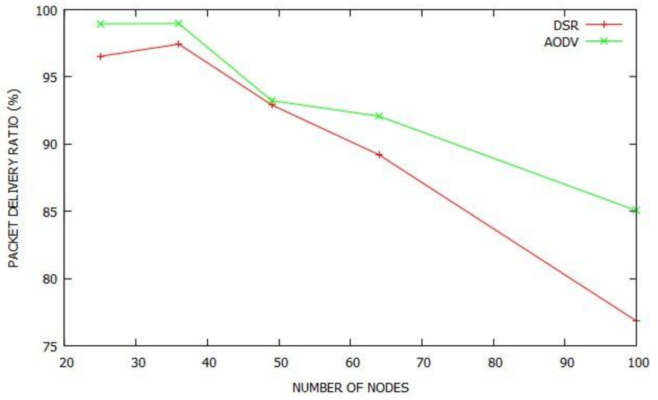

Figure 2. Packet Delivery Ratio Graphic for maximum speed of 1 and the node number is varying from 25 to 100

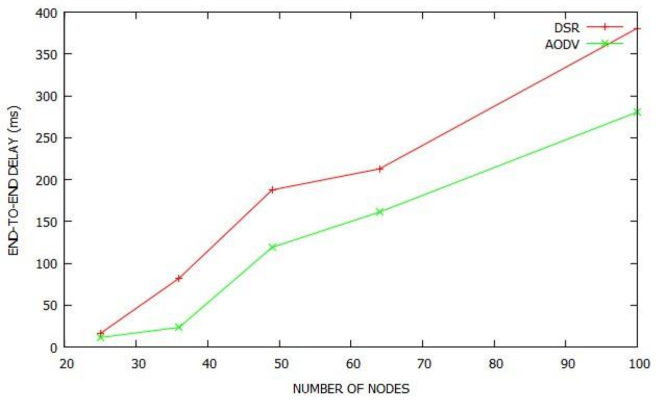

Figure 3. Average End-to-end Delay Graphic for maximum speed of 1 and the node number is varying from 25 to 100

Packet delivery ratio is defined as the ratio of data packets received by the destinations to those generated by the sources. Mathematically, it can be defined as: PDR= S1÷ S2. Where, S1 is the sum of data packets received by the each destination and S2 is the sum of data packets generated by the each source. Graphs show the fraction of data packets that are successfully delivered during simulations time versus the number of nodes. Performance of the AODV is reducing regularly while the PDR is increasing in the case of DSR and AODV. AODV is better among the two protocols. Figure 2 shows that AODV have very good packet delivering ratio in large number of nodes comparing to DSR.

The average time it takes a data packet to reach the destination. This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue. This metric is calculated by subtracting time at which first packet was transmitted by source from time at which first data packet arrived to destination. Mathematically, it can be defined as: Avg. EED=S/N. Where S is the sum of the time spent to deliver packets for each destination, and N is the number of packets received by the all destination nodes. Figure 3 shows that AODV performs best in case of average end-to-end delay. DSR is On-demand source routing protocol, and this is the major reason for it having a higher end-to-end delay. AODV on the other hand has only one route per destination in the routing table, which is constantly updated based on sequence number, which leads to a slight delay in delivery.

IV. Conclusions

This work compared the performance of AODV and DSR routing protocols for MANETs with different maximum speed of 1, 5, 10 and 20 using NS-2 simulations. Both AODV and DSR perform better under high mobility simulations. High mobility results in frequent link failures and the overhead involved in updating all the nodes with the new routing information less in AODV and DSR, where the routes are created as and when required. The performance of MANET reactive routing protocols have been analyzed under random mobility model with respect to three quantitative performance metrics (Throughput, Packet-delivery ratio and End-to-end Delay). Both protocols were compared in terms of throughput packet loss ratio and end-to-end delay, with mobile nodes varying number of nodes and speed.

The simulation results in shows that throughput and packet delivery ratio is high for less number of nodes in DSR and high for more number of nodes in AODV, where as in end-to-end delay the performance is high for DSR and low for AODV in all the five scenarios (25, 36, 49, 64, 100 nodes) as well. DSR and AODV both use on-demand route discovery, but with different routing mechanics. In particular, DSR uses source routing and route caches, and does not depend on any periodic or timer-based activities.

DSR exploits caching aggressively and maintains multiple routes per destination. AODV, on the other hand, uses routing tables, one route per destination, and destination sequence numbers, a mechanism to prevent loops and to determine freshness of routes. The general observation from the simulation is that for application-oriented metrics such as packet delivery delay AODV, outperforms DSR in more "stressful" situations (i.e., smaller number of nodes and lower load and/or mobility), with widening performance gaps with increasing stress (e.g., more load, higher mobility). DSR, however, consistently generates less routing load than AODV. The poor performances of DSR are mainly attributed to aggressive use of caching and lack of any mechanism to expired stale routes or determine the freshness of routes when multiple choices are available.

Acknowledgment

This work was supported by Seoul National University of Science and Technology.

References

[1] Bansal, Meenakshi, Rachna Rajput, and Gaurav Gupta. "Mobile ad hoc networking (MANET): Routing protocol performance issues and evaluation considerations." The Internet Society (1999).

[2] D. B. Johnson and D. A. Maltz, "Dynamic Source Routing in Ad hoc Networks," Mobile Computing, ed. T. Imielinski and H.Korth, Kluwer Academic Publishers, vol. 353, pp. 153-181, 1996.

[3] Charles E. Perkins, Ad Hoc Networking, Addison-Wesley Professional, 2008.

[4] E.M. Royer, "A review of current routing protocols for ad hoc mobile wireless networks", IEEE Personal Communications, vol. 6, no. 2, pp. 46-55, 1999.

[5] C. E. Perkins and E.M. Royer, "The ad hoc on-demand distance vector protocol," Proceedings of the Second IEEE Workshop on Mobile Computing Systems and Applications, pp. 90-100, 1999.

[6] Maltz, David B. Johnson David A., and Josh Broch. "DSR: The dynamic source routing protocol for multi-hop wireless ad hoc networks." Computer Science Department Carnegie Mellon University Pittsburgh, 2001.

[7] Broch, Josh, David A. Maltz, David B. Johnson, Yih-Chun Hu, and Jorjeta Jetcheva. "A performance comparison of multi-hop wireless ad hoc network routing protocols", In Proceedings of the 4th annual ACM/IEEE international conference on Mobile computing and networking, pp. 85-97, 1998.

[8] Md Shohidul Islam, Md Naim Hider, Md. Touhidul Haque, Leton miah "An Extensive Comparison among DSDV, DSR and AODV Protocols in MANET", International journal of computer application (0975-8887), vol. 15, no. 2, pp. 22-24, 2011.

[9] Awos Kh. Ali., "Performance Evaluation of MANET Routing Protocols for Varying Topologies Size," J. Edu. & Sci., vol. 25, no. 3, pp. 82-94, 2012.

[10] H. Kaur and Er. J. Singh, "Performance comparison of OLSR, GRP and TORA using OPNET," International Journal of Advanced Research in Computer Science and Software Engineering, vol. 2, no. 10, pp. 260-267, 2012.

[11] Johnson, D., Y. Hu, and D. Maltz, "DSR: RFC 4728", URL: http://www. ietf. org/rfc/rfc4728.txt, 2010.

[12] Perkins, Charles, Elizabeth Belding-Royer, and Samir Das, "RFC 3561-ad hoc on-demand distance vector (AODV) routing" Internet RFCs, pp. 1-38, 2003.

[13] Fall, Kevin, and Kannan Varadhan, "The network simulator (ns-2)", URL: http://www. isi. edu/nsnam/ns, 2007.

[14] Camp, Tracy, Jeff Boleng, and Vanessa Davies, "A survey of mobility models for ad hoc network research", Wireless communications and mobile computing 2, no. 5, pp. 483-502, 2002.

[15] Chiang, Kuo-Hsing, and Nirmala Shenoy, "A 2-D random-walk mobility model for location-management studies in wireless networks", IEEE Transactions on Vehicular Technology, vol. 53, no. 2, pp. 413-424, 2004.

[16] Bettstetter, Christian, Giovanni Resta, and Paolo Santi, "The node distribution of the random waypoint mobility model for wireless ad hoc networks", IEEE Transactions on Mobile Computing, vol. 2, no. 3, pp. 257-269, 2003.

[17] Carofiglio, Giovanna, C-F. Chiasserini, Michele Garetto, and Emilio Leonardi, "Route stability in MANETs under the random direction mobility model", IEEE Transactions on Mobile Computing, vol. 8, no. 9, pp. 1167-1179, 2009.

[18] Tuch, B. J, "An ISM Band Local Area Network: WaveLAN", In IEEE Workshop on Local Area Networks, pp. 103-111, 1991.