International Journal of Research and Reviews in Ad hoc Networks (IJRRAN)
Vol. 1, No. 4, December 2011, ISSN: 2046-5106

www.sciacademypublisher.com

Applications of MANET Routing Protocols in Sensor Network

Venetis Kanakaris, David Ndzi, and Kyriakos Ovaliadis

Department of Electronic and Computer Engineering, University of Portsmouth, Portsmouth, United Kingdom

Abstract - In wireless sensor networks power consumption is a crucial issue because most of the sensor nodes operate using batteries. The purpose of this paper is to evaluate four routing protocols (OLSR, AODV, DSR, DSDV) in different wireless sensor network (WSN) scales regarding the power consumption and mobility factor. In small networks with less than 10 nodes the four protocols have similar performance. On the other hand, when the number of nodes is increased the performance of the OLSR protocol was poor in terms of power consumption and MAC load, while AODV, DSR and DSDV protocols produced very good results. DSDV routing protocol shows a very good performance in terms of power in all scenarios but suffers from poor packet routing in large scale networks.

Keywords - Ad Hoc Network, Power Aware Routing, Routing Protocols, Wireless Sensor Network, AODV, DSDV, DSR, OLSR

1. Introduction

Recent advances in technology especially in the field electronic systems have led to the development and use of low powered sensors. A significant number of areas where sensors are being used or envisaged to be used require the sensors to operate wirelessly as a network with the number of nodes and configuration being dependent on the application. A Wireless Sensor Network (WSN) thus consists of tiny sensor nodes communicating with each other, and deployed from small to large scales. The existing wireless technology is based at the point-to-point technology. This kind of network is used in areas such as environmental monitoring or in rescue operations. Wireless systems, both mobile and fixed, have become an indispensable part of communication infrastructure. Their applications range from simple wireless low data rate transmitting sensors to high data rate real-time systems such as those used for monitoring large retail outlets. The main limitation of ad-hoc systems is the availability of power. In addition to running the on-board electronics, power consumption is governed by the number of processes and overheads required to maintain connectivity. This paper focuses on communication protocols specifically aimed at limiting power consumption and prolonging battery life whilst maintaining the robustness of the system. Moreover proposes further research into more efficient protocols or variants of existing protocols such as OLSR [1] and network topologies. Emphasis is on protocols that could be suitable for the implementation of scalable systems in high node density environments such as in manufacturing or product distribution industries.

Optimized Link State Routing protocol (OLSR) [1] [12] is a proactive protocol which uses “Hello” message and Topology Control (TC) messages in order to discover and disseminate link state information throughout the Wireless Sensor Networks (WSN). The dissemination of those TC messages influences the performance of the network, measured in terms of energy consumption. There are many algorithms except OLSR which focuses on energy efficient routing such as Dynamic Source Routing (DSR) [2], Ad-Hoc On Demand Routing (AODV) [3] and Destination-Sequenced Distance Vector (DSDV) [4]. These protocols offer varying degrees of efficiency.

In [5] comparisons have been made of four ad-hoc routing protocols in terms of power consumption and the results showed that Temporally Order Routing Algorithm (TORA) performs poorly while AODV presents very good results in terms of power consumption. The main objective of this paper is to analyze the OLSR routing protocol for efficiency in terms of power and compare it with the other three protocols and suggest ways that its performance could be improved. This will be made by measuring the energy consumption in with in different network sizes and taking into consideration the remaining battery power.

1.2 Types of WSN Routing Protocols

The WSN routing protocols [5] are mainly developed to maintain route inside Mobile Ad-Hoc Networks (MANETs), and they do not use any access points to make connection with other nodes in the network. Routing protocols can be classified into three categories depending on their properties. The classifications are:

- Centalized
- Table driven
- On demand driven (Source initiated)

In centralized algorithms, all route choices are made by a central node, while in distributed algorithms, the computation of routes is shared amongst the network nodes. In static algorithms, the route used by source-destination pairs is fixed regardless of traffic condition. It can only change in response to a node or link failure. This type of algorithm cannot achieve high throughput under a broad variety of traffic conditions. In adaptive routing, the routes used between source-destination pairs may change in response to congestion. A third classification that is more related to ad-hoc networks is to classify the routing algorithms as either proactive or reactive.

1.3 Table driven Routing Protocols

Table driven protocols maintain one or more routing tables in every node in order to store routing information about other nodes in the network. The nodes update the routing table information either periodically or in response to changes in the network. The advantage of this class of protocols is that a source node does not need route-discovery procedures to find a route to a destination node. On the other hand the drawback of these protocols is that maintaining a consistent and up-to-date routing table requires substantial messaging overhead, which consumes bandwidth and power, and decreases throughput, especially in the case of a large number of high-mobility nodes. There are various types of table driven protocols which include Destination Sequenced Distance Vector routing (DSDV), Wireless routing protocol (WRP) [7], Fish eye State Routing protocol (FSR), Optimized Link State Routing protocol (OLSR), Cluster Gateway switch routing protocol (CGSR), Topology Dissemination Based on Reverse path forwarding (TBRPF).

1.4 On Demand Routing Protocols

In this class of protocols there is an initialization of a route discovery mechanism by the source node to find the route to the destination node when the source node has data packets to send. When the process finds the route, the route maintenance is initiated to maintain this route until it is no longer required or the destination is not reachable. The advantage of these protocols is that overhead messaging is reduced compared to proactive protocols. One of the drawbacks of these protocols is the delay in discovering a new route. The different types of Reactive routing protocols include; Dynamic Source Routing (DSR) [7], Ad-hoc On-Demand Distance Vector routing (AODV) and Temporally Ordered Routing Algorithm (TORA).

This paper is organized as follows; Section 2 introduces the four protocols (OLSR, DSDV, DSR and AODV) that will be evaluated in this paper whilst Section 3 describes the parameters that have been used in the assessment of the performances of the protocols using simulation. Section 4 presents the results from the simulation and the conclusions are drawn in Section 5.

2. Routing Protocols

OLSR [1] is a routing protocol where the nodes keep information of all available routes. As an optimized version of the pure link state protocol, the OLSR protocol floods the network with information update when the topology changes. One way of reducing the overhead in the network is to use Multipoint Relays (MPR). MPR [13] works by reducing the number of duplicate re-transmissions when a broadcast packet is forwarded. Using this technique the number of re-transmissions is restricted to a small set of neighbour nodes, instead of using all the nodes in the neighbourhood. This set is kept as small as possible by choosing nodes which cover (in terms of one-hop radio range) the same network region as the complete set of neighbouring nodes. The OLSR routing protocol uses two kinds of the control messages:

1. Hello
2. Topology Control

Hello messages are used in order to establish the link status and the host's neighbours. On the other hand TC messages are used for sending information about own advertised neighbours which includes the MPR selector list.

The OLSR protocol has a disadvantage in that every node periodically sends the updated topology information to the entire network, increasing the bandwidth usage. But this issue is solved by using the MPR, which forwards only the messages regarding the topology of the network.

In DSDV [4] routing messages are exchanged between nearby mobile nodes (i.e. mobile nodes that are within range of one another). Routing updates may be triggered or routine. Updates are caused when routing information from one of the neighbours forces a change in the routing table. If there is a packet which the route to its destination is unknown it is cached whilst routing queries are sent out. The packets are cached until route-replies are received from the destination. The buffer has a limited time for caching packets whilst waiting for routing information beyond which packets are dropped. All packets which have route information to destination node are routed directly. In the event that a target is not found (which happens when the destination node of the packet is not the mobile node itself), the packets are forwarded to the default target which is the routing agent. The routing agent designates the next hop for the packet and sends it down to the link layer.

In DSR [2] protocol the agent checks every data packet for source-destination route information. The packets are then forwarded as per the routing information. In case it cannot find any routing information in the packet, it provides the source route if route is known and when the destination is not known it caches the packet and sends out route queries. The route query is initially sent to all nearby nodes and is always triggered by a data packet which has no route information. Route-replies are send back either through the destination node or by intermediate nodes, to the source, and this happens if it can find routing information to the destination in the route-query.

AODV [3] it is a mix of both DSR and DSDV protocols. It keeps the basic route-discovery and route-maintenance of DSR and uses the hop-by-hop routing sequence numbers and beacons of DSDV. When a node needs to know a route to a specific destination it creates a Route Request (RREQ). Next the route request is forwarded by intermediate nodes which also create a reverse route for itself from the destination. When the request reaches a node with route to destination it creates again a Route Reply (RREP) which contains the number of hops that are required to reach the destination. All nodes that participate in forwarding this reply to the source node create a forward route to destination. This route created from each node from source to destination is a hop-by-hop state and not the entire route as in source routing.

3. Simulation and Metrics

In this research we have used 70 nodes in a area with dimensions of 500x300 square meters. The nodes can be moved with speed which is dynamically changed from 0 m/s to 20 m/s. Moreover the nodes are moving independently and they can stop only for millisecond and then continue to move for next 100 milliseconds until to stop again and so on. The scenario lasts 200 seconds. For simplicity, in all cases only two senders with Constant Bit Rate (CBR) over User Datagram Protocol (UDP) and two receivers have been used.

The aim of the simulations was to analyze the OLSR protocol comparing with other protocols (AODV, DSR, and DSDV) for its efficiency in terms of power as well as throughput. This has been achieved by measuring the energy with respect to different network sizes and taking into consideration the remaining battery power. The simulation tool that has been used in this study is ns2 [8].CMU's (Communication Management Unit) wireless extension to ns2 provides the implementation of the DSR, AODV, DSDV, OLSR routing protocols.

Table1: Parameters of the Simulation

Channel type	Wireless Channel
Radio-propagation model	TwoRayGround
Antenna type	OmniAntenna
Interface queue type	DropTail/PriQueue
Maximum packet in Queue	50
Network interface type	Phy/WirelessPhy
MAC type	802_11
Topographical Area	500 x 300 sq.m
txPower	0.5W
rxPower	0.1W
idlePower	0.01W
Initial energy of a Node	1000.0 Joules
Routing protocols	AODV/DSDV/DSR/OLSR
Number of mobile nodes	10,20,30,40,50,60,70
Mobility	0 to 20m/s

The performances of the protocols have been analysed for networks with 10 to 70 nodes and mobility up to 72 km/h (20 m/s).

3.1 *Metrics considered for Evaluation [9]*

Number of Packets dropped: The number of data packets that are not successfully sent to the destination node. In this study, the number of packets dropped per unit time is calculated.

Remaining Battery Power: The number of nodes in the network against the average remaining battery power is used to analyse the performance of the protocols in terms of power.

Consumed Power: The number of nodes in the network versus the average consumed battery power, is evaluated as a power performance indicator. This parameter is, however, changes commensurate to the remaining battery power. Nonetheless it provides useful information about the remaining lifespan of each node in the network before node failure that could lead to network partition.

Throughput: This measures the performance of the network in terms of provision of constant data to the sink. Throughput is the number of packet arriving at the sink per millisecond.

MAC Load: The ratio of the number of MAC layer messages propagated by every node in the network and the number of data packets successfully delivered to all destination nodes. In other words, the MAC load means the average number of MAC messages generated to each data packet successfully delivered to the destination.

Dropped Packets: The number of data packets that are not successfully sent to the destination node during the transmission process.

4. Results and Analysis

The following two graphs show the results of power analysis.

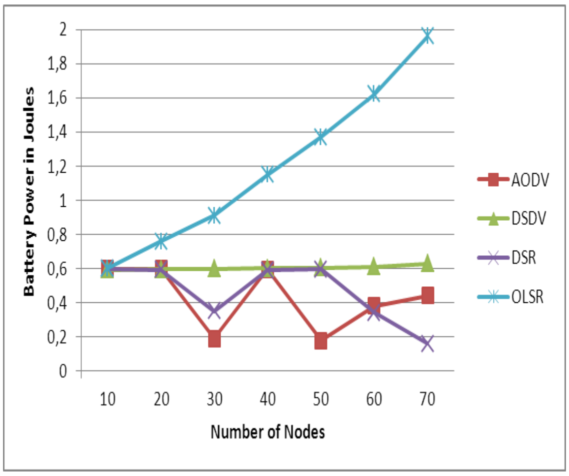

Figure 1: The number of nodes versus the average consumed power

Figure 1 shows that the consumed power of network using OLSR icreases rapidly when tha number of nodes exceeds 20. This is caused because the OLSR protocol floods the network with information update when the topology changes and by this way is caused depletion of battery energy. On the contrary, the consumed power of a network using DSR and AODV decreases depended from the number of nodes that are at the neighbourhood. Both of these protocols use methods to find valid routes by following complete different methods of that the OLSR which causes flooding into whole network. The DSDV protocol presents a stability at the power consumption as it has a mechnism of finding a valid route be using a technic which excahnges routing messages between nearby mobile nodes.

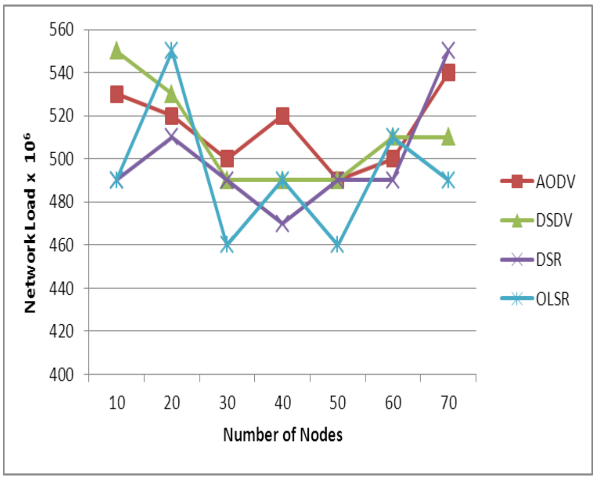

Figure 2: The number of nodes versus Network Load

At figure 2, the AODV and the DSR presents almost the same attitude except in the area of 40 nodes where DSR has decreased network load while the AODV has the same network load as in 20 nodes network. On the other hand the OLSR protocol presents very steep changes of the network load starting from 10 and 20 nodes where shows an increased network load, while on the area between 30 and 50 nodes the network load is decreasing more gentle as in the network with 60 and 70 nodes. Finally the DSDV protocol shows a steep reduction of network load until the number of nodes becomes 30, then when the number of nodes is between 30 and 50 the network load is stable and starts to increase when the network has more than 50 nodes. This happens because the pairs of the mobile nodes which exchanging topology information are increasing rapidly when the density of the network consist of more than 50 nodes.

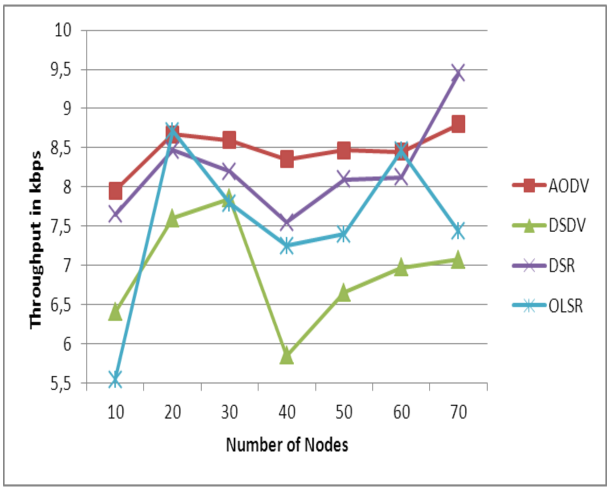

Figure 3: The number of nodes versus throughput

Figure 3 shows that the throughput of AODV and DSR protocols presents a very stable behaviour in every scale of the network. On the other hand OLSR and DSDV presents the same behaviour when the number of nodes are 20 and 40 but after that, the thrughput of OLSR decreasing rapidly when the number of nodes is between 30 and 50. OLSR has the lowest throughput when the network has less than 10 nodes while the other three protocols present an increased throughput.

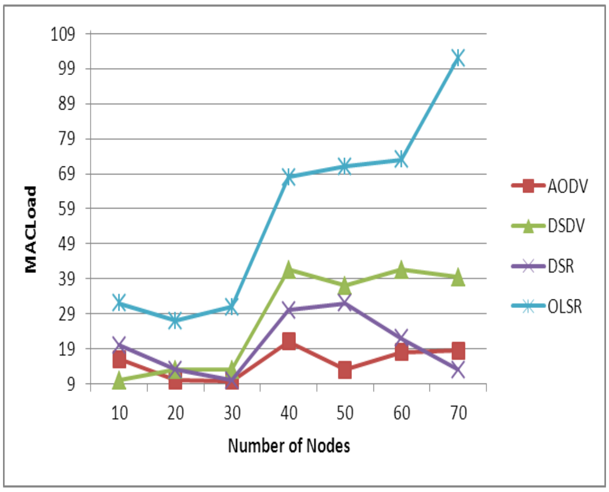

Figure 4: The number of nodes versus MAC Load

Figure 4 shows that the MAC Load icrease rapidly when the number of nodes exceeds 30 for OLSR protocol and become almost stable when the number of nodes is between 40 and 60. This behaviour is due to the complete flooding that the protocol causes is order to discover routes. The DSDV presents a very low MAC Load when the network consists of less than 30 nodes and increases rapidly when the number of nodes exceed the 30 and the pairs of nodes that exchanging topology information become more. The DSR routing protocol presents almost the same behaviour with DSDV when the number of nodes is as low as 30 but after that the MAC Load increases rapidly until the number of nodes is 50 and decreases steeply until the number of nodes is 70. In high density networks the DSR routing protocol shows low MAC Load because the nodes that contain information about topology are more and so the MAC Load will be less. On the other hand the MAC Load of the AODV protocol almost stable in every scale of the network due to the RREQ mechanism that the protocol uses in order to discover routes.

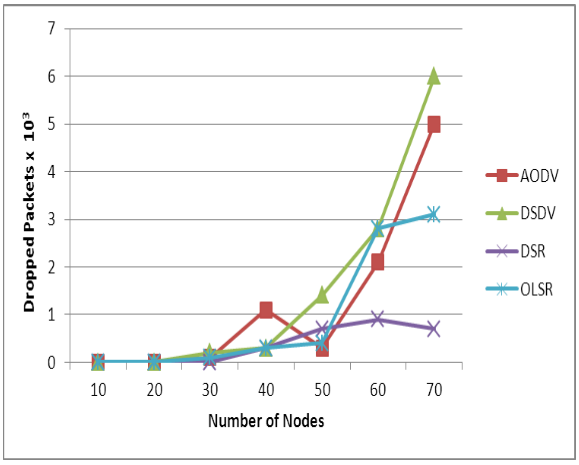

Figure 5: Number of nodes versus the Dropped Packets

Figure 5 shows the relationship between the number of nodes and the dropped packets. This figure shows that the AODV, DSDV and the OLSR protocol becomes inefficient when the network consists of more than 50 nodes for high density network. This situation results an increased number of re-transmissions in order to re- send the packets and reach the destination node. On the contrary the DSR protocol presents a very good behaviour in small and large networks and gives very good results in terms of dropped packets. By this way it avoids redundant re-transmissions that the other three routing protocols have and gives an advantage at the DSR protocol in terms of power consumption.

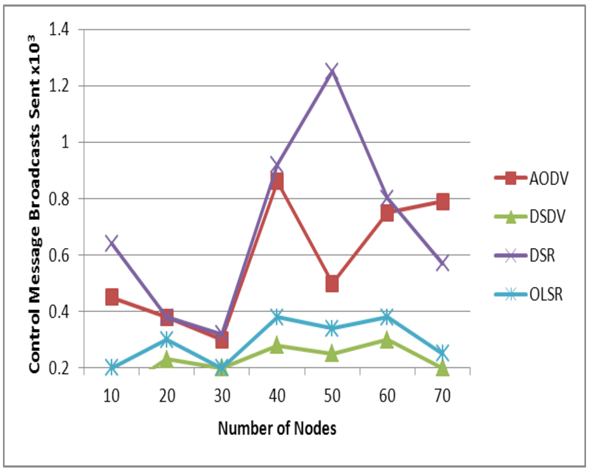

Figure 6: The Number of nodes versus Total Control Message Broadcasts Sent

Figure 6 shows how the number of nodes affects the Total Control Message Broadcasts Received in all the four protocols. This figure shows that AODV and DSR send more messages than the other two protocols OLSR and DSDV. This also means that the network load of those two protocols AODV and DSR will be very high unlike the other two protocols and especially when the number of nodes is between 40 and 60. On the other hand DSDV and OLSR presents very good results in all range of the network and show very low number of total control message broadcast sent.

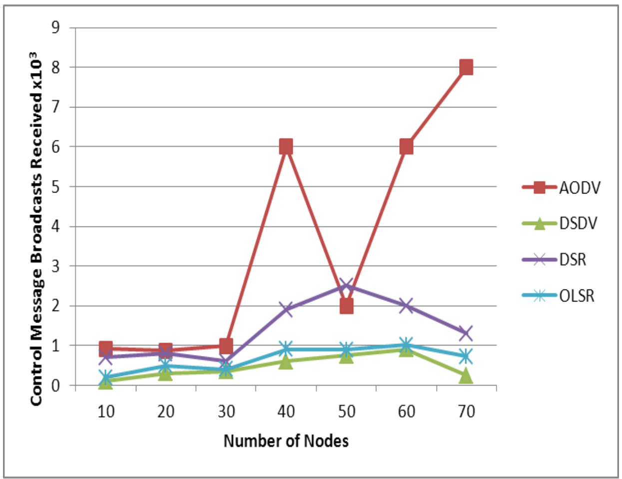

Figure 7: The Number of nodes versus Total Control Message Broadcasts Received

Figure 7 shows how the number of nodes affects the Total Control Message Broadcasts Received in all the four protocols. This figure shows that AODV receives more messages than the other three protocols DSR, OLSR and DSV and this happens because when the number of nodes increased more than 40 there will be more receptions of the nodes in order to establish a connection. This also means that the throughput of AODV protocol will be very high unlike the other three protocols. The DSR routing protocol it has very high throughput when the number is exceeded the 30 but it lower that the throughput of the AODV. On the other hand the OLSR and the DSDV showed the lowest control message broadcasts received from the other two protocols (AODV, DSR) in all range of the network.

The evaluation of these four protocols made by Network Simulator (ns2). During experimenting with OLSR and the other three protocols on ns2, it was realized that the ns2 implementation of OLSR needs some modification by adding a patch [14].

5. Conclusions

We have evaluated four routing protocols in different wireless sensor network environment by also taking into consideration the mobility factor. In smaller networks, the performance was comparable. But in medium and large size networks, the OLSR routing protocol seemed to be inefficient in terms of power as well as in MAC Load. The performance of AODV, DSDV and DSR in small size networks was comparable. But in medium and large size networks, the AODV and DSR produced almost the same results with OLSR protocol. On the other hand the DSDV protocol was the only one which had constant performance in almost all scenarios. We noticed that OLSR and DSDV have almost the same behaviour regarding the Total Control Messages, and this happens because both of them use techniques decreasing flooding.

6. References

[1] Rango F. D., Fotino M., Marano S., "EE-OLSR: ENERGY EFFICIENT OLSR ROUTING PROTOCOL FOR MOBILE AD0HOC NETWORKS", Military Communications Conference, IEEE, Nov. 2008, pp. 1-7.

[2] D. Maltz, Y. Hu, "The Dynamic Source Routing Protocol for Mobile Ad Hoc Networks", Internet Draft, July 2004, Available: http://www.ietf.org/internet-drafts/draft-ietf-manet-dsr-10.txt

[3] C. Perkins and E. Royer, "Ad Hoc On-demand Distance Vector (AODV) Routing", Internet Draft, MANET working group, draft-ietf-manet-aodv-05.txt, March2000.

[4] A. H. Abd Rahman, Z. A. Zukarnain, " Performance Comparison of AODV, DSDV and I-DSDV Routing Protocols in Mobile Ad Hoc Networks ", European Journal of Scientific Research Vol.31, No.4, June 2009, pp. 556-576

[5] V. Kanakaris, D. Ndzi, D. Azzi, "Ad-Hoc Networks Energy Consumption: A review of the Ad-Hoc Routing Protocols", Journal of Engineering Science and Technology Review, pp. 162-167, Vol. 3, Iss. 1, 2010

[6] L. Junhai, X. Liu, Y. Danxia, " Research on multicast routing protocols for mobile ad-hoc networks" Science Direct Vol. 52 Issue 5, April 2008, pp. 988-997

[7] M. Abolhasan, T. Wysocki, E. Dutkiewicz, " A review of routing protocols for mobile ad hoc networks ", Science Direct Vol. 2, Issue 1, January 2004, pp. 1-22

[8] "Ns-2 network simulator," http://www.isi.edu/nsnam/ns/, 1998.

[9] A. Rahman, S. Islam, A. Talevski, " Performance Measurement of various Routing Protocol in Ad-Hoc Network ", IMECS, Vol. 1, March 2009, pp. 321-323.

[10] "CMU Monarch extensions to ns2," http://www.monarch.cs.cmu.edu/cmu-ns.html, 1999.

[11] Marc Greis' Tutorial for the UCB/LBNL/VINT Network Simulator "ns"

[12] Benslimane A., El Khoury R., El Azouri R., Piere, S. "Mobile Computing and Wireless Communication International Conference, MCWC,", Sept. 2006, pp. 14 -19

[13] A. Qayyum, L. Viennot, A. Laouiti, "Multipoint Relaying for Flooding Broadcast Messages in Mobile Wireless Networks," 35th Annual Hawaii International Conference on System Sciences (HICSS'02), Jan. 2002 Volume 9, pp.298

[14] "Installing OLSR on ns2",http://masimum.inf.um.es/um-olsr/html, 2005